AMERICAN ENGINEER AND RAILROAD JOURNAL.

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CONTENTS.


| ARTICLES ILLUSTRATED: | Page |
|---|---|
| American Engineer Tests | 297 |
| Shops at Collinwood, L. S. & M. S. | 299 |
| Light for Roundhouses, Increased | 307 |
| Cars, New Electric, for Rapid Transit Subway in New York | 308 |
| Locomotive, New Switching, L. S. & M. S. | 317 |
| Repair Facilities for Steel Cars | 318 |
| Triple-Pressure Riveter, Bement, Miles & Co. | 320 |
| Truck Bolster and Brake Beams, Vanderbilt | 324 |
| Horizontal Boring and Milling Machine, Franklin | 325 |
| Mortising and Boring Machine, Bentel & Margedant Company | 326 |
| Diagram Showing Graphic Method of Finding Limit Diameters of Axles (reproduced from our August issue) | 321 |

| ARTICLES NOT ILLUSTRATED: | Page |
|---|---|
| Alternating-Current System, New, for Electric Railway Operation | 306 |
| Economy of Steam Turbines | 307 |
| Reliability of Gas Engines | 309 |
| Steel Rails. Specifications | 310 |
| Relation Between Heating Surface and Cylinder Power | 313 |
| Scrap, Locomotive and Car | 315 |
| Lighting of Roundhouses, Night | 319 |
| Tractive Force of Locomotives | 322 |
| Transport Facilities, New, for Ontario | 324 |
| Water Tube Boilers in Marine Practice | 324 |
| Electric Railway System, Large | 325 |
| Personals | 326 |
| Books and Pamphlets | 327 |
| Equipment and Manufacturing Notes | 328 |
| EDITORIALS: | Page |
| The Collinwood Shops | 312 |
| Heat Treatment of Steel | 312 |
| The Shop as a School | 312 |
| Comparison of Locomotives | 313 |


## AMERICAN ENGINEER TESTS.

### LOCOMOTIVE DRAFT APPLIANCES.

### X.

Report by Professor Goss.

SECTION IV. (Continued from Page 184.)

Editor's Note.—At this point it seems appropriate to introduce a letter from Herr Von Borries because of the importance of his opinions, which are based upon a thorough knowledge of both American and foreign practice. His reference to high back pressure in American locomotives should be considered in connection with the statement on page 303 of our October number of last year: "On some of these cards the back pressure is from 20 per cent. to 25 per cent. of the mean effective pressure. In other words, from 16 to 20 per cent. of the total power developed by the engine is employed in creating the draft necessary for combustion." It should be mentioned that in the particular case referred to here, the locomotive had a smaller nozzle than was required, but the illustration fairly represents conditions which are prevalent in large high speed passenger locomotives.

To the Editor:

In Professor Goss' report, Article VIII., on his most interesting preliminary trials of locomotive draft appliances, I find on page 134 of the May number of your valuable paper the statement for the distribution of the draft, according to which some one-third of it is required to overcome the resistance given by the diaphragm plate. From this statement it seems to me that the draft in American locomotives, which generally use that plate, must be some 50 per cent. higher than in European locomotives, which do not use this plate. Consequently the back pressure on the pistons must be higher in a similar measure, causing a higher consumption of coal for accomplishing the same work.

I believe it would be well to extend the trials on draft, also to include the question whether the diaphragm plate is really necessary.

Here we do not use it, but give the blast pipe such a position that the fire burns equally over the whole grate and the gases are distributed equally over the tubes. In our former trials we found that lowering the blast pipe caused more draft through the lower tubes and the back part of the grate, while raising it gave the contrary effect. Therefore there is one position which causes equal draft, and we always try to find it out practically for new types of engines. Generally the formulas I gave as a result of our trials for the dimensions of the stack and blast pipe have proved sufficient. Sometimes small corrections have been found economical.

A. VON BORRIES.

Hanover, Germany, May 24, 1902.

## A STUDY OF LIMITING CONDITIONS.

### CONTINUATION OF REPORT.

(See June number, page 184.)

23. Height of Choke Above Top of Nozzle.—This distance, as shown by the drawings reviewed, is quite variable for the same size of engine on different roads, and seems to follow no law. It is 45 ins. for 64-in. boxes; 50 ins. for 68-in. boxes, and 52 ins. for boxes 72, 76 and 80 ins. in diameter.

24. Conclusions as to Stacks.—The diameter at the choke of 14 ins. is used to a considerable extent for the largest modern passenger engines, and 16 ins. at the choke and 18 ins. at the top represent average practice for freight engines. The diameter of the stack at the smoke-box joint is as small as 17½ and as large as 24 ins. The average diameter, therefore, may be taken as 22 ins. While there is no uniformity in practice relative to the height of the choke from the top of the smoke-box, the prevailing practice is represented by a height of 14 ins., though this height is reduced to from 3 or 4 ins. when smoke-boxes are above 80 ins. in diameter. The height of the stack above the smoke-box is governed largely by the height of the boiler from the rail, but it averages 36 ins. The height of the choke above the top of the nozzle averages from 45 to 52 ins., for smoke-boxes from 64 to 80 ins. in diameter.

25. Nozzles.—The diameter of nozzles cannot be definitely fixed by reference to other proportions, but the aim is to make them as large as consistent with good steaming. The exhaust base and single nozzle, similar to the proportions recommended by the committee of the Master Mechanics' Association in 1899, seem to be generally used to-day. On one of the principal roads the choke is in the cylinder saddle instead of its usual position in the exhaust base. This is used with a high saddle, where the distance from the center of the cylinder to the bottom of the smoke-box is 2 ft. 9 ins. and the top of the partition of the choke is 6 ins. below the exhaust base joint on the saddle. The choke itself is 10 ins. below the smoke-box. In this construction the exhaust base is like a straight open pipe without a partition, and the total height of the base and the nozzle above the saddle is 20 ins. in smoke-boxes 72 to 74 ins. in diameter.

26. The Height of Nozzle is usually given as the total height of base and tip above the bottom of the smoke-box. It is evident that this dimension can have little significance if its relations to other dimensions are important and are to be considered. For example, a nozzle 24 ins. high would have its tip 3 ins. below the center of the 55-in. smoke-box of the Purdue locomotive, 11 ins. below the center of boiler on a 68-in. smoke-box, and 18 ins. below the center of the boiler in an 84-in. smoke-box. (See Fig. 20.) In the first case the tip would be 32 ins. below the stack base; in the second case, 44 ins., and in the third case, 60 ins. All these different relations are for an

exhaust nozzle 24 ins. high, and for this reason it is thought that the position of the tip in the smoke-box, with relation to other draft fixtures, would be more definitely fixed if expressed in inches below the center line of the boiler.

27. Average Height of Nozzle.—If the smoke-boxes are arranged in groups varying by intervals of 4 ins. in diameter, from 64 to 80 ins., and the average distance of top of nozzle

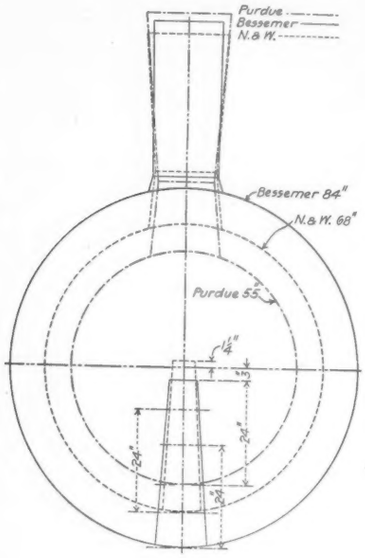


Fig. 20.

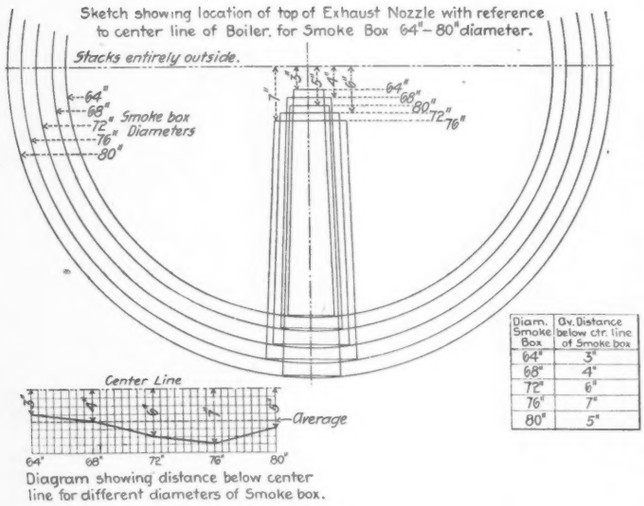


Fig. 21.

below center line is obtained for each group, the showing will be about as follows:

| Diameter of Smoke Box. | Average Distance of Top Below Center Line of Smoke Box. |
|---|---|
| 64 ins. | 3 ins. |
| 68 ins. | 4 ins. |
| 72 ins. | 6 ins. |
| 76 ins. | 7 ins. |
| 80 ins. | 5 ins. |

These relations are also well shown by Fig. 21, in which the diameters of the smoke-box and height of the nozzle are drawn to scale. It will be seen that the range of heights of nozzles for smoke-boxes of various diameters on large boilers is small, and the distance below the center line varies from 3 to 7 ins. This distance increases with the diameter until the 80-in. smoke-box is reached, when the height is 5 ins. below the center. All this suggests that a height of nozzle 3 to 5 ins. below the center line can be used successfully on boilers having smoke-boxes 64 to 80 ins. in diameter, and it is quite probable that a height of 4 ins. below the center would answer for all of them.

It may be said, therefore, that for modern locomotive boilers of from 64 to 80 ins. in diameter, having the stack entirely outside the smoke-box, the top of nozzle is very nearly 4 ins. below the center line of the boiler. As already mentioned in connection with inside stacks, the nozzles with such designs are much below the center of the boiler. The examples, the drawings for which have been reviewed, are similar to those shown in Fig. 19, with inside stacks on boilers from 70 to 74 ins. in diameter; the distance from the center of the boiler to the top of the nozzle is 15 ins., 20 ins. for passenger engines, and 17 ins. for freight engines.

28. Conclusions as to Nozzles.—The diameter of the nozzle is not considered within the scope of this investigation.

The height of nozzle is best shown by its relation to the center line of the boiler, and when so measured the variation for smoke-boxes of widely different diameters is found to be small, it being 3 ins. for 64-in. boxes and 5 ins. for 80-in. boxes, and it is safe to conclude that good practice is well represented by a distance of 4 ins. below the center of the boiler in smoke-boxes from 60 to 80 ins. in diameter.

The relation of the top of the nozzle to the choke of the stack has been considered under paragraph 22, but we may repeat that the range appears to be from 45 to 52 ins. for smoke-boxes from 64 to 80 ins. in diameter.

(End of Professor Forsyth's report. The report by Professor Goss is to be continued.)

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The importance of strong cars is emphasized by the railroad commissioners of Michigan, in their annual report for 1901, in the following words: "A practice that cannot go into disuse too rapidly is that of operating light passenger coaches of insufficient strength. The loss of life in time of collision or other accident wherein the car strain is a factor is notably less when strong cars are used and equally prominently greater when weak cars are used. Good railroad management discovered this long ago, and I am glad to state that it is my belief that an ambition begets all railroads to as soon as possible operate only the strongest, heaviest and best possible cars." Unquestionably, strength and safety should be considered as the first rule of car construction. It is believed to be possible, however, to increase the strength of cars and decrease the risk of crushing in collisions, and at the same time actually reduce the weight by the use of steel floor structures and steel platforms.

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The Aurora, Elgin & Chicago Electric Railway, running between Chicago, Wheaton, Aurora and Elgin, Ill., begun operation August 25, running passenger trains to connect with the Metropolitan Elevated Railway in Chicago. Trains are run at 30-minute intervals and at speeds averaging 45 miles per hour, including stops. By this service important suburban districts and outlying towns will have the advantage of frequent trains, rapid transit and an ideal method of distribution over the loop tracks and connections in the city of Chicago. This is the sort of competition the steam roads need to watch.

---

The present high prices for scrap are specially favorable to railroads having a large number of small capacity cars to tear down. The "per diem" agreement seems to have brought a lot of small cars home on many roads, and it is reported that within a month about 15,000 cars will be scrapped in Chicago alone, which will yield about 100,000 tons of scrap iron and steel.

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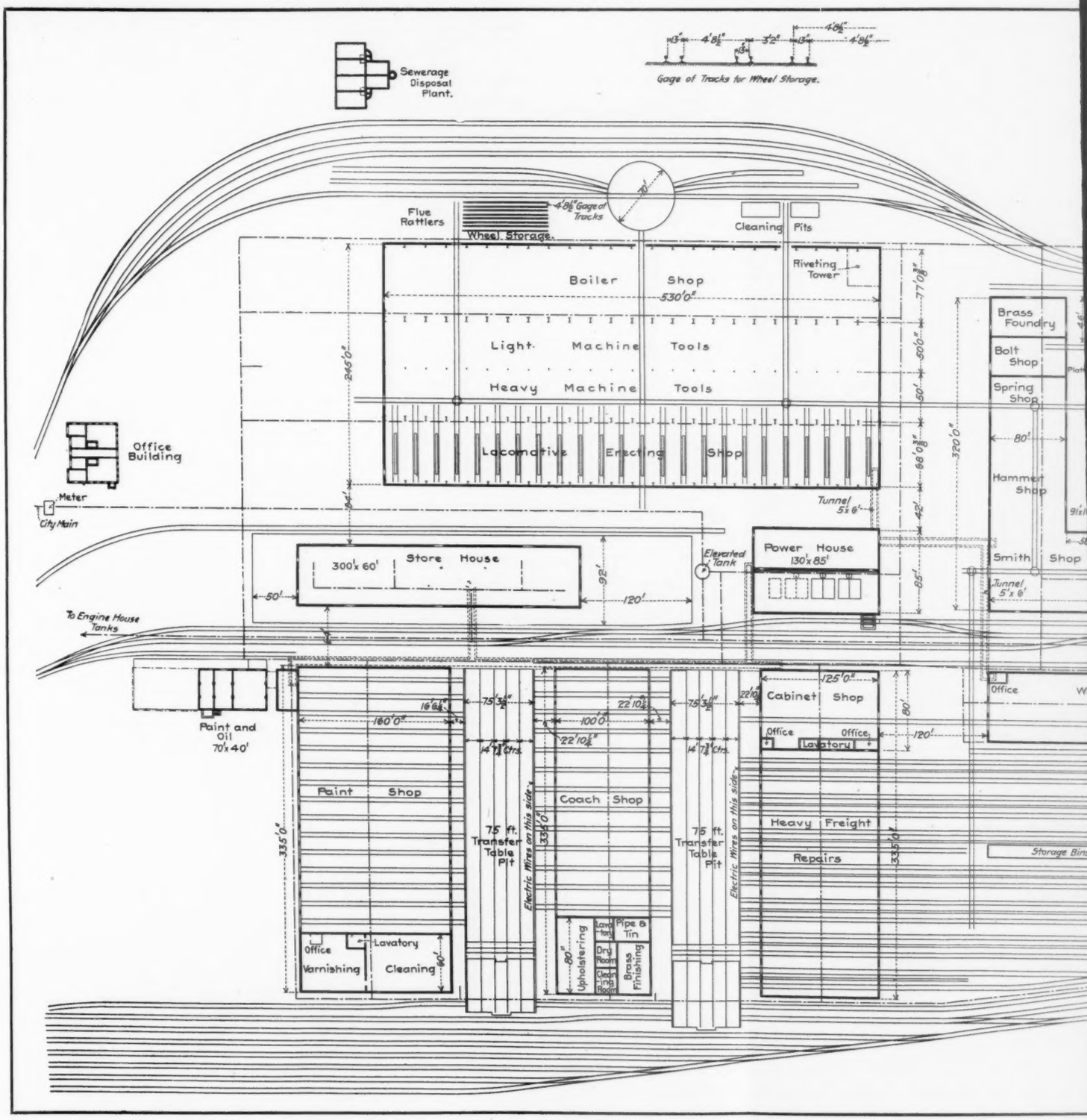
The steam yacht Arrow in a trial trip last month on the Hudson River made a mile at the rate of 39.13 knots, or 45 miles, per hour, using 4,000 horse-power. The steam pressure was from 350 to 400 lbs., and the engines made from 540 to 600 revolutions. The length of the boat is 130 ft.

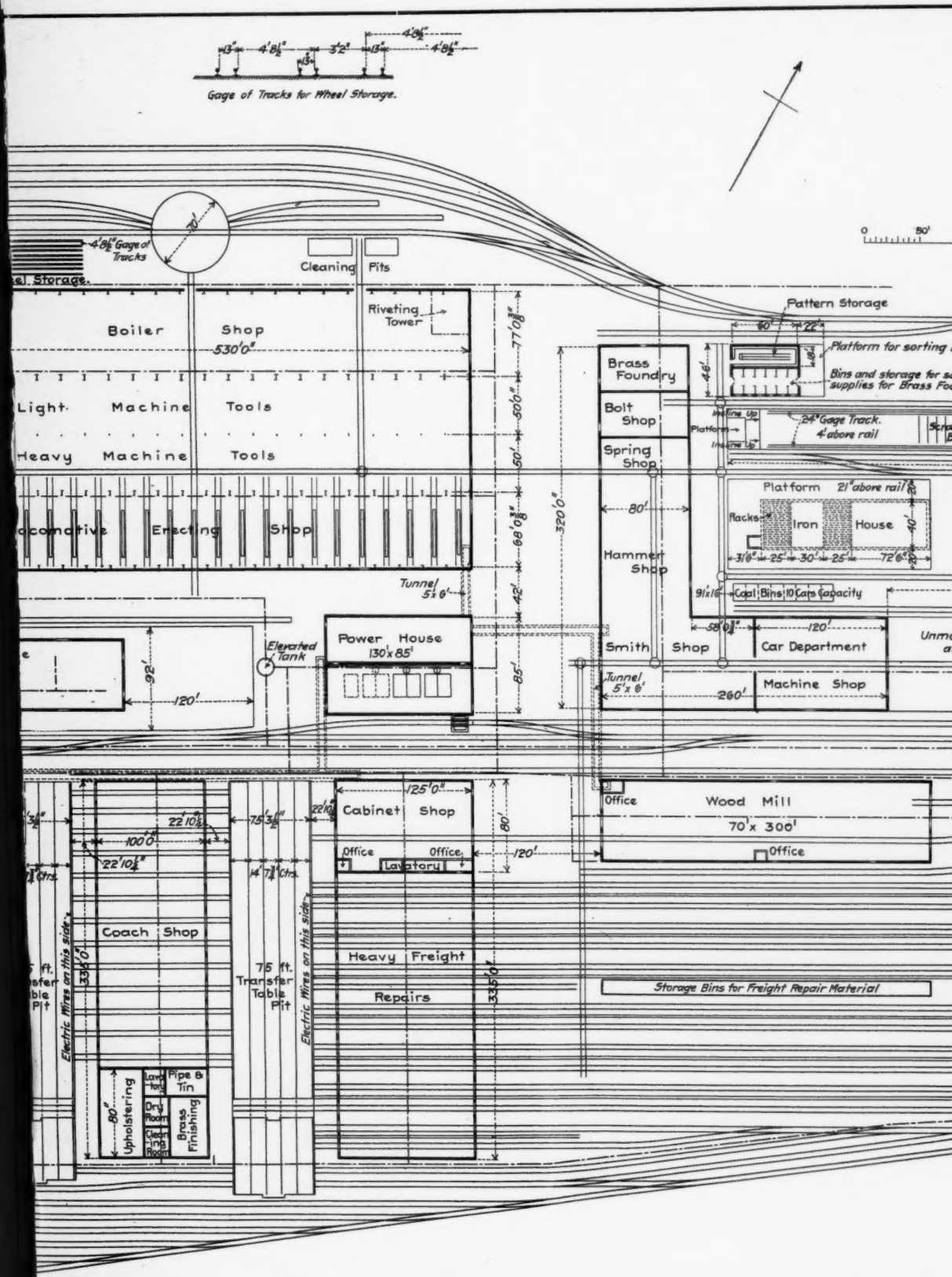



## LOCOMOTIVE AND CAR SH

COLLINWOOD, OHIO — LAKE SHORE & MICHIGAN SOU

H. F. BALL, *Superintendent Motive Power.*
H. H. VAUGHAN, *Assistant Superintendent Motive Power.*

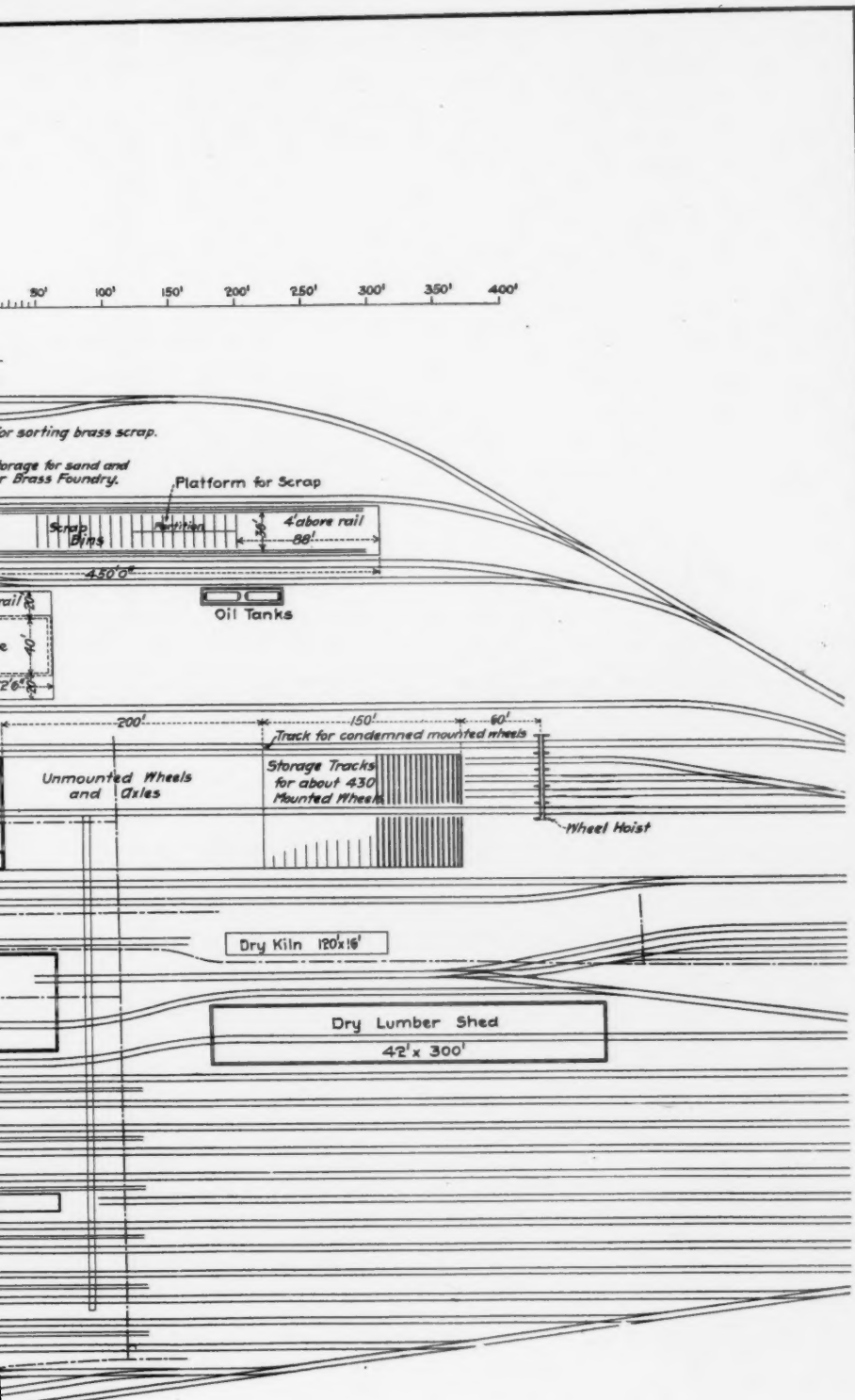
W. H. MARSHALL, *General Superintendent.*




# LOCOMOTIVE AND CAR SHOPS.

COLLINWOOD, OHIO — LAKE SHORE & MICHIGAN SOUTHERN RAILWAY.

W. H. MARSHALL, *General Superintendent.*




AY.

E. A. HANDY, *Chief Engineer.*
A. LUCIUS, *Consulting Engineer.*

## NEW LOCOMOTIVE AND CAR SHOPS.

### Collinwood, Ohio.

### Lake Shore & Michigan Southern Railway.

### With an Inset.

### I.

These interesting shops are now going into service, and through the courtesy of the officers of the road they will be described in a series of articles in this journal. The plan throughout originated with the motive-power department, and the construction has been carried out with the hearty co-operation of the engineering department. The underlying idea was to meet the business problems involved, in a plant which is ample for present needs and provides for extension to meet the increased demands of many years. The plant is thoroughly modern and business-like, but it does not involve expense which is not justified by operating results.

The work was begun and nearly completed under the direction of Mr. W. H. Marshall while he occupied the position of superintendent of motive power. He was ably assisted by Mr. H. F. Ball, the present superintendent of motive power, and by Mr. H. H. Vaughan, the present assistant superintendent of motive power. The buildings and preparation of the grounds were under the charge of Mr. E. A. Handy, chief engineer, and the details of the buildings were worked out by Mr. Albert Lucius, of New York, consulting engineer.

#### Location and Capacity.

This road has shops at Elkhart, Ind., and required another with modern facilities near the eastern end of the line, where the business is very much heavier. A central location would be desired if the business was uniform, but naturally in this case the location was selected toward the eastern end. Furthermore, the main line is divided into four divisions, and the Elkhart shops are easily reached by all locomotives on the two divisions immediately east of Chicago. By placing the new shops at Collinwood (near Cleveland) all main-line engines east of Toledo are easily accessible to these shops, so that with the present arrangement all main-line engines pass a main shop in the course of every round trip.

At the present time about 350 locomotives per year will come to Collinwood for heavy and light repairs, the ultimate capacity of the present facilities being 450 per year. With the present output of 350 locomotives, 29 will pass through the shops per month. These shops will take care of two-thirds of the locomotive work for the entire system. The shops at Elkhart, while old, are still serviceable and can easily maintain the power on the two western main-line divisions and all the Michigan branches. Many of the heavier engines for the entire road requiring extensive work will go to Collinwood to take advantage of the crane and other facilities. The excellent machine equipment at Collinwood will also permit of making all stock locomotive repair material, which is required in quantities, at that point.

#### Car Shops.

The car-department buildings are now being erected, the foundations being nearly completed. These will take care of the entire passenger-car equipment of the Lake Shore system. This involves an important business principle in concentration, as every passenger car on the system is put through the shops for either partial or complete overhauling once every year. It is intended that the entire equipment shall be dealt with in nine months of each year, releasing the passenger equipment entirely for the three summer months when traffic is heaviest. About 500 passenger cars will be maintained here, but facilities will be furnished for handling 550 in nine months, to be called upon when needed. During the season of light work, or when, for any reason, the shops are not working to their full capacity, it is intended to build whatever baggage or mail cars may be needed.

Collinwood is also to be important as a freight-car repair point. The present freight repair shops at Ashtabula, Englewood and Toledo will be maintained, the only change being a large increase of the Cleveland facilities at Collinwood. The same principle that applies to locomotive repair work will be introduced into the car work, as to making stock for repair material at Collinwood. This shop will be the most important freight-repair plant on the road, but there will be no effort made to concentrate these repairs there.

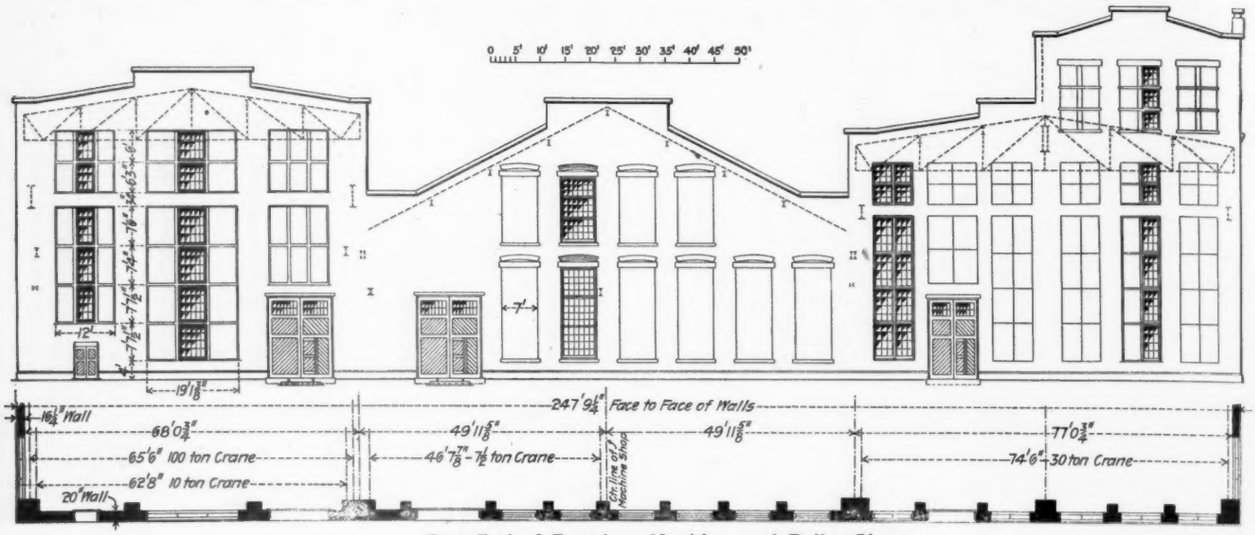
#### General Description.

With the main line at the south and private property on the north, the plot was limited in width, and the general plan in the inset accompanying, shows how well the space is used. With the power-house and storehouse at the center, the buildings are grouped in a way which gives ample space between them, good passageways, and convenient means for transporting material. The distances for moving the material are direct and short, considering the size of the plant. Too much cannot be said of the storehouse location and facilities. The large raised platform, 92 ft. by 120 ft., at its eastern end, is a feature. The power-house is the heart of the lay-out. The combination of brass foundry, bolt shop, spring shop, smith shop and car-department machine shop in an L-shaped building placed between the storage yard, scrap-bins, wheel storage and the main locomotive shop, and within easy reach of the car shops, is very convenient and compact. Everything will move in straight lines throughout the plant, and this includes the lumber and all other material. The blacksmith shop is east of the locomotive shop, with a through track for heavy material, which extends also through the storage space. The north end of the blacksmith shop is the hammer department, with forges down on each side, while the south end has the bulldozers, forging machines and their furnaces. The car-department machine shop will handle car-wheels, axles and necessary machine work on car forgings, which are delivered there direct from the blacksmith shop, and the bolt shop concentrates all of this work for the entire plant. Lumber for car work is brought in from the east end of the yard, and passes through the lumber kiln and lumber shed to the wood mill, and from there to the car-repair shops over the track westward from the mill.

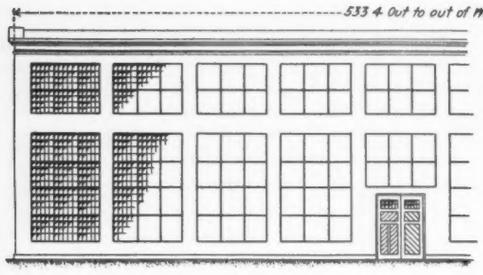
#### Locomotive Shops.

The locomotive shop is a noble building, 530 by 245 ft., combining all of the locomotive work under one roof, with plenty of cranes, unusual natural lighting, general convenience, and a single system of heating for the whole. This building is impressive in its generous width and the general substantial character of its construction. Heavier steelwork and masonry are seldom seen in buildings of this character, and it may be expected to remain an up-to-date building for many years. Daylight lighting is better than in any other railroad shop. In this respect it closely resembles the shops of the New York Navy Yard and the machine shop of the Chicago Shipbuilding Company. There are 24 pits at 22-ft. centers in the erecting shop. At the north of this shop is a 70-ft. turntable. There is no transfer table for handling locomotives.

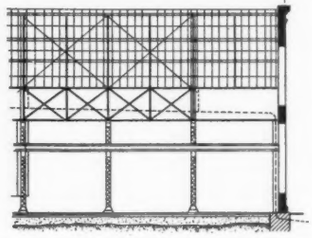
By adopting the transverse track, locomotives are handled by a single crane, which was preferred to the other plan requiring two large cranes. Furthermore, the plan adopted was considered more convenient. The officers of the road believe, however, that where good crane service is provided the arguments for and against transverse or longitudinal tracks are not as strong as they would be where crane service is limited or entirely absent. In deciding upon the width of the various bays, the erecting shop was made wide enough to give plenty of room for the longest engines and the pit tracks were made long enough to give storage room for the wheels, extending part of their length into the machine-shop bays. By doing this the span of the large crane for handling engines was



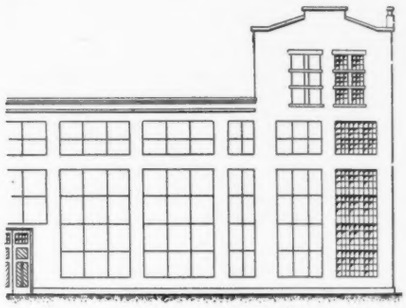

East End of Erecting, Machine and Boiler Shops.



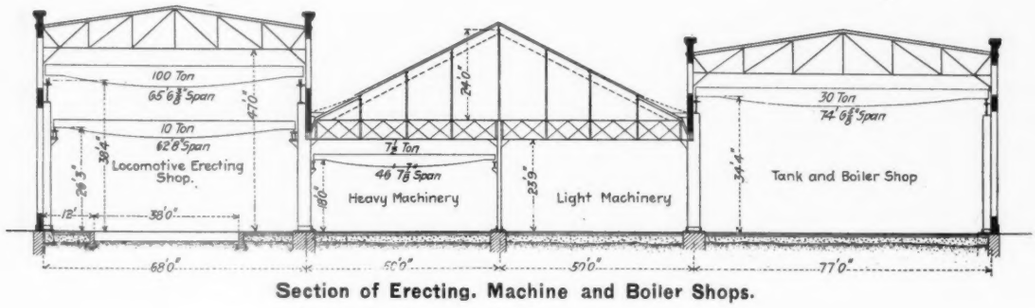

Part Elevation of Engine Shop.



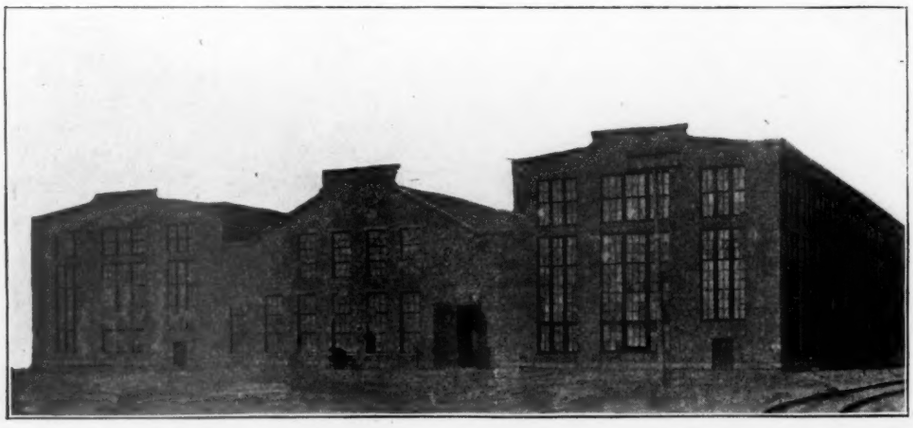
Part Section Through Center of Machine Shop.



Part Elevation of East Corner of Tender Shop.

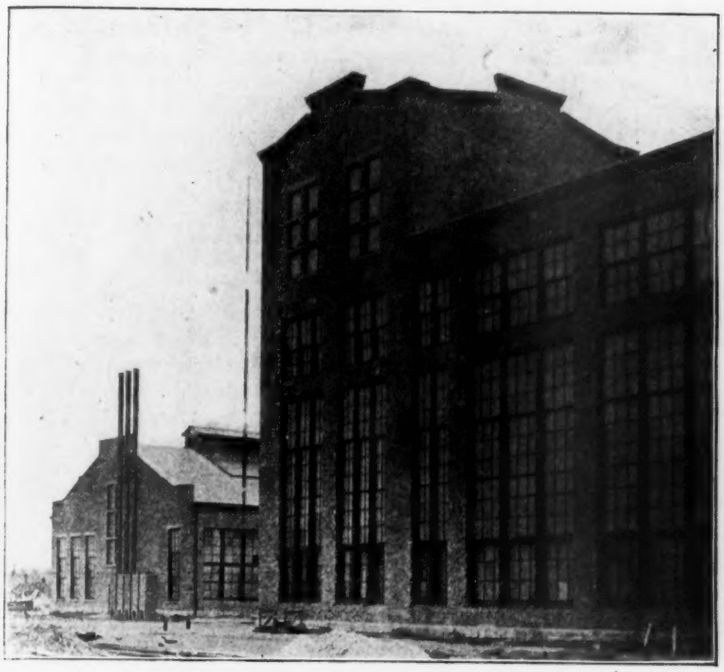



Section of Erecting. Machine and Boiler Shops.

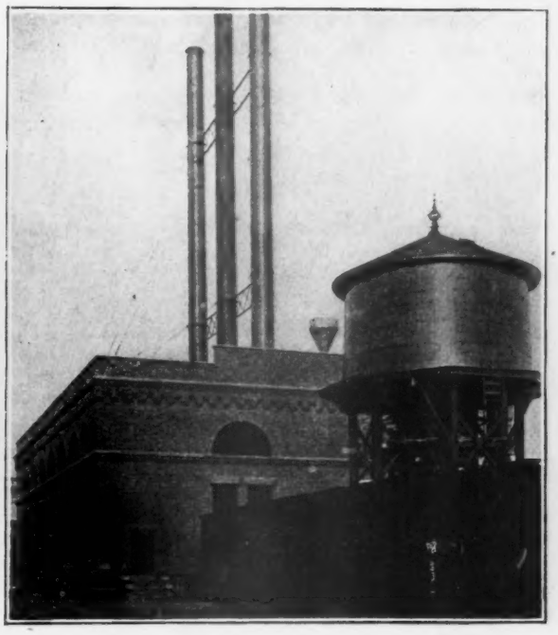


West End of Boiler, Machine and Erecting Shops.

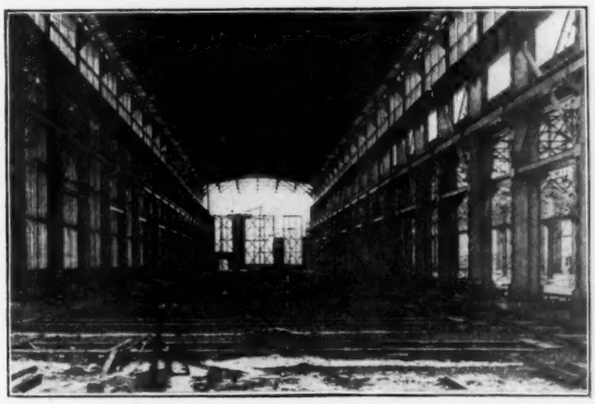
Locomotive and Car Shops, Collinwood, Ohio.—Lake Shore & Michigan Southern Railway



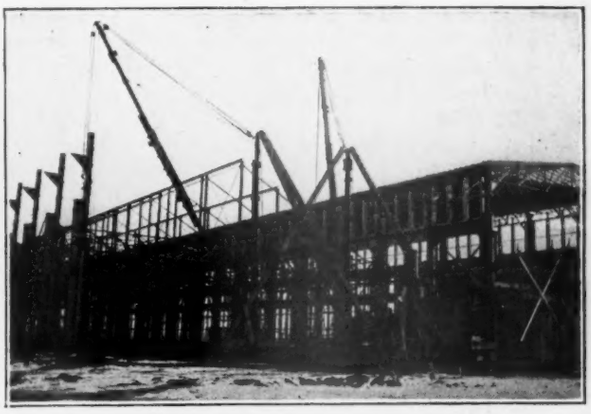
Northeast Corner of Boiler Shop, Showing Riveting Tower.



West End of Power House.



Construction View of Erecting Shop.



Exterior Construction View of Machine Shop.

Interior Construction View of Machine Shop.

Interior View of Boiler Shop.

Locomotive and Car Shops, Collinwood, Ohio.—Lake Shore & Michigan Southern Railway.

shortened, making the erecting bay a convenient and economical width and enabling the wheels to be handled by the cranes in both the erecting and machine shops without further transfer. The width of the boiler shop was determined with reference to the handling of boilers and tenders, leaving sufficient space along one side for the necessary machine tools. The machine shop was made very much wider in proportion to the rest of the plant than is usual in railroad shops, because the erecting floors do not limit the output of the plant. This limit is usually the machine space, and by making it large in proportion to the erecting floor more engines may be dealt with per year on each track than could be handled otherwise. The amount of work which can be obtained from one track on the erecting floor is dependent upon the number of men employed in that work, and the output is flexible, whereas if the machine space is not large enough to begin with it is impossible to overcome the difficulty. This machine shop is large, and it may be made larger if necessary by providing for the driving wheels in some other location.

The first impression given by the location of the toilet facilities in the main shop and the smith shop is unfavorable, but this soon changes to approval. With perfect protection to the health of the men there is no valid objection to placing them within the buildings, and this location renders it unnecessary for any but laborers in handling material to leave the shop upon any pretext.

Locomotives enter the shop over the turntable at the north side of the building. They are taken south into the erecting shop and distributed among the pits by the large crane. This shop will be illustrated and described in detail in another article. The steam pipes, air and water pipes are placed in large underground tunnels connecting the various buildings and centering at the power-house. At the northwest corner of the grounds is a sewage disposal plant, which was made necessary by the local conditions. At the extreme west end is an attractive office building for the master mechanic and master car builder and their clerical forces, the chemist and engineer of tests, shop drafting room and chemical laboratory. This building is near the road and the entrance to the grounds. It is well adapted in size, arrangement and lighting for its purpose, and is more comfortable than many of the quarters provided for general officers, but is not expensive or elaborate.

### Extension of Plant.

This plan provides for extension in any direction. The locomotive shop may be extended west, the storehouse west, the paint shop by additional buildings south of the paint and oil storehouse. East of the blacksmith shop building is a brass-foundry storehouse and pattern shop. South of this is a scrap platform 450 ft. long, partly divided into bins, so that scrap may be handled, after sorting, by cars, or it may be moved west to the small platform to go to the smith or bolt shop. South of the scrap platform is an iron house, in which all iron is stored for the smith and bolt shops. Finished forgings and brasses will be stored at this point. South of the iron house are coal and coke bins for the smith shop. The tracks north of the locomotive shop are for storage of locomotives awaiting repairs, and on this side of the shop are the cleaning pits and flue-rattlers; also storage tracks for wheels. Storage for about 430 mounted wheels is provided east of the car-department machine shop.

### Buildings.

The buildings, except the storehouse, have very little wood about them. The steelwork is very heavy. In the locomotive shop there are 2,150 tons of steel, the building being approximately 60 ft. high by 530 ft. long and 250 ft. wide, with posts 52½ ft. high. This building, being very long, has brick ends, for two reasons—to give bulkhead bracing and to dispose of the problem of expansion.

The blacksmith shop also has heavy steelwork, and a load of 10 tons may be hung to the roof trusses at any point. In locating a large hammer a load about 50 per cent. in excess of this was placed upon the middle of one of the trusses.

The walls are ample, as indicated in the drawings, and so also are the foundations, which are of concrete made in the proportions of 3 parts of sand and 5 of stone to 1 of cement. A base course of 18-in. stone starts the walls above the foundations around the entire locomotive-shop building, except at the ends, and this is cut out for the steel posts. At the ends this course is 23½ ins. thick. The end walls are 20 ins. thick to the top of the first tier of windows, and 16 ins. thick above that to the top. The rich red color of the brick is an attractive feature of the buildings.

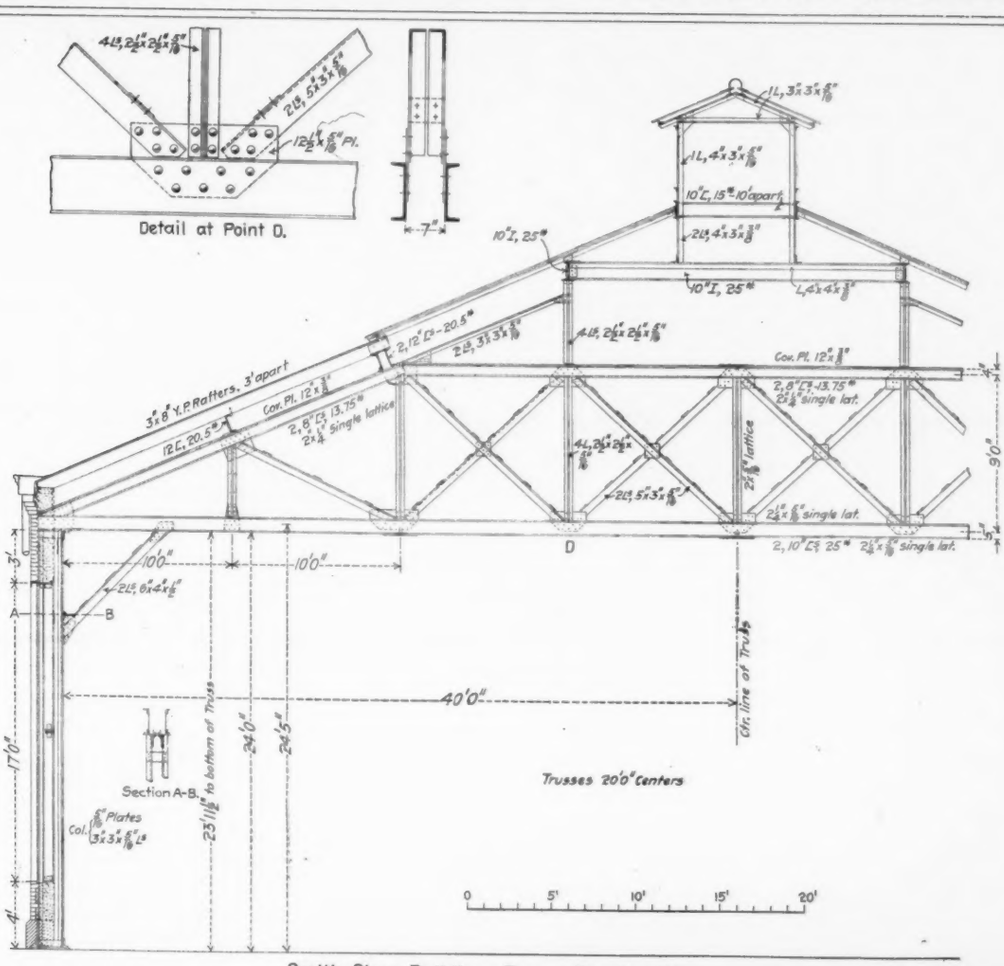
The steel frame of the locomotive shop is specially interesting. That of the erecting shop is so rigid that in standing upon the roof or on any member of the framing when a locomotive is lifted by the cranes, no indication of the load is given. The main steel frame consists of two rows of posts placed in each of the main walls of the erecting and boiler shops and one row of posts on the center line of the machine shop. The posts are braced in pairs, forming fixed sections, braced and riveted, alternating with unbraced sections, to provide for local expansion. The posts in the outside walls are very interesting, and will be illustrated in our next article. They carry the girders for the cranes and the roof trusses only. Those in the inner walls carry the additional load of the machine-shop roof and the walls above that roof, with their proportion of the weight of the shafting. The posts at the center of the machine shop carry their portion of the load of the roof, which is of glass, that of a small traveling crane and their part of the shafting. The steelwork of the main window sections and of the doors in the outer walls is framed in and fastened to the posts. The roof trusses are also braced in pairs, forming fixed sections, alternating with unbraced sections, all fixed sections being riveted up rigidly, while the unbraced sections are carried on seats and shelves and connected by fishplates with holes sufficiently large for local expansion. The roof over the light-machine shop is subdivided by secondary girders into sections of 11-ft. span to carry the line and countershafting.

The floor of the locomotive shop has a top surface of tongued and grooved maple 6 ins. wide, dressed, 1 in. thick, laid on 3-in. yellow pine plank, varying from 8 to 12 ins. in width, supported on 6 by 4-in. nailing strips spaced at 2-ft. centers. These strips are graded to the level of the under side of the floor, which corresponds to the top of the timber covering of the hot-air ducts, which are under the floor. To permit of such grading, a space of 1 in. is provided between the top of the asphalt binder and the bottom of the nailing strips. Sand is used for grading. The entire floor of the main building is filled with clean gravel, packed and rolled. This is covered with a 4-in. layer of asphalt binder made of small-sized broken stone mixed hot with hot asphalt and tar binder mixture, of one gallon to every cubic foot of stone. No water can come from underneath to rot the floor.

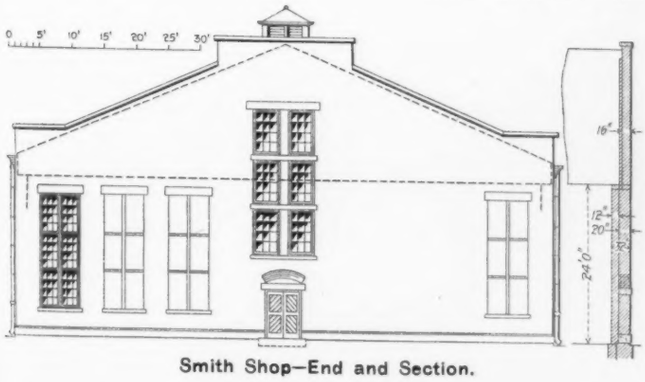
The roof joists carrying the roof boards of the boiler shop, riveting tower, erecting shop, and the sides of the machine-shop roof, below the skylights, are of 3 by 8-in. yellow pine, seven of them being employed in each 22-ft. panel. Upon these, tongued and grooved 1-in. hemlock boards are laid. The roofs are covered with asphalt laid in five-ply roofing felt. The pitch of the erecting and boiler-shop and riveting-tower roofs is 1¾ ins. per foot, while that of the machine shop is 6 ins. Over the felt is a layer of crushed roofing gravel.

Over the machine shop is a skylight 80 by 530 ft., of ¾-in. ribbed glass, 22 ins. wide and 6 ft. long, making 22 panels, which are supported on the steel frame. These sections correspond with the fixed and expansion sections of the steel frame of the building. The windows have steel frames and wooden sash, with the lower sash movable, and all lower sashes are protected by wire netting.

Inside drainage is provided for the roofs, with the main leaders secured to the roof trusses. This construction will



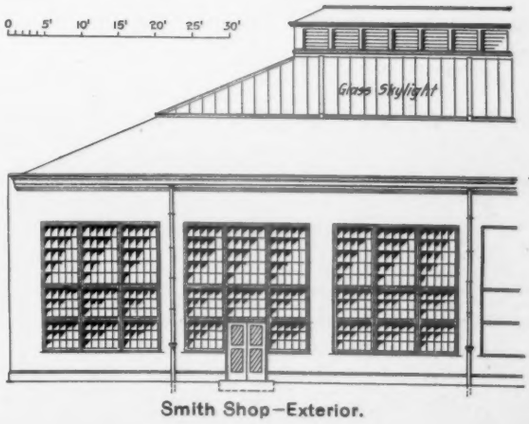

Smith Shop Building—Frame Construction.



Smith Shop—End and Section.

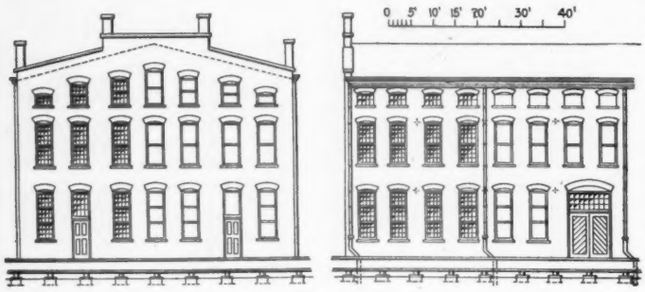
Smith Shop—Showing Corner.

Office Building.




Smith Shop—Exterior.

Locomotive and Car Shops, Collinwood, Ohio—Lake Shore & Michigan Southern Railway.

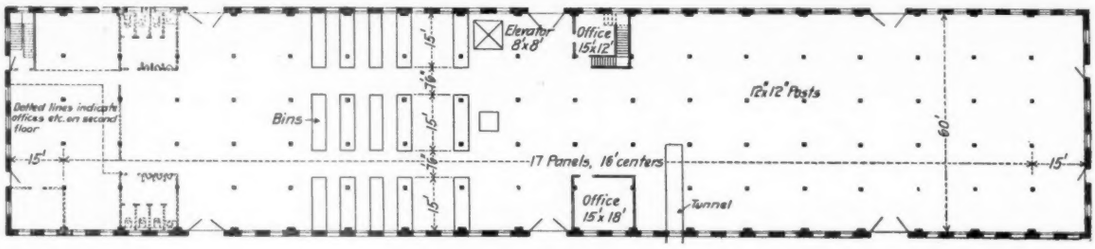



Storehouse—End and Partial Side Views.

prevent all trouble from freezing. The details of one of the roof gutters will be illustrated next month.

### Storehouse.

The storehouse is a 60 by 300-ft. brick building of three stories, with floors of heavy wood construction. An extensive platform, 4 ft. high, surrounds the building, and is reached by tracks on both sides. This building has a 5,000-lb. electric elevator, delivering material to all floors. Instead of placing the storehouse in the charge of any particular department, in this case the storekeeper reports to the general manager and serves all departments. The stationery stock for the entire road forms an important item of this department.




Storehouse—First Floor Plan.

### FLOOR AREAS OF SHOP BUILDINGS.

#### LOCOMOTIVE DEPARTMENT.

| | |
|---|---|
| Erecting shop (530 x 68) = | 36,040 sq. ft. |
| Machine shop (530 x 100) = | 53,000 sq. ft. |
| Boiler and tank shop (530 x 77) = | 40,810 sq. ft. |
| Total locomotive shops (530 x 245) = | 129,850 sq. ft. |
| Blacksmith shop, including spring, hammer and smith shops (300 x 80) = | 24,000 sq. ft. |
| Bolt shop (40 x 80) = | 3,200 sq. ft. |
| Brass foundry (40 x 80) = | 3,200 sq. ft. |
| Total locomotive department shops = | 160,250 sq. ft. |

PERCENTAGE OF TOTAL LOCOMOTIVE DEPARTMENT SHOPS (160,250 sq. ft.)

| | |
|---|---|
| Erecting shop | 22.5 |
| Machine shop | 33.0 |
| Boiler and tank shop | 25.5 |
| Brass foundry, bolt and total blacksmith shops | 19.0 |
| | 100.0 |

RELATION TO ERECTING FLOOR AREA, IN PER CENT.:

| | |
|---|---|
| Machine shop | 1.47 |
| Boiler and tank shop | 1.13 |
| Brass foundry, bolt and total blacksmith shops | .84 |

#### CAR DEPARTMENT.

| | |
|---|---|
| Coach shop, total (335 x 100) = | 33,500 sq. ft. |
| Cabinet shop (125 x 80) = | 10,000 sq. ft. |
| Paint shop, total (335 x 160) = | 53,600 sq. ft. |
| Total passenger shops = | 97,100 sq. ft. |
| Machine shop, car (120 x 80) = | 9,600 sq. ft. |
| Freight repair shop (255 x 125) = | 31,875 sq. ft. |
| Wood mill (300 x 70) = | 21,000 sq. ft. |
| Upholstering, pipe and tin, and brass finishing sections of coach shop (100 x 80) = | 8,000 sq. ft. |
| Cleaning and varnishing sections of paint shop (160 x 60) = | 9,600 sq. ft. |
| Paint and oil building (70 x 40) = | 2,800 sq. ft. |

PERCENTAGE OF TOTAL PASSENGER CAR SHOPS (97,100 sq. ft.)

| | |
|---|---|
| Coach shop | 34.5 |
| Paint shop | 55.2 |
| Cabinet shop | 10.3 |
| | 100.0 |

Upholstering, pipe and tin, and brass finishing section = 23.8 per cent. of total coach shop.

Cleaning and varnishing section = 17.9 per cent. of total paint shop.

#### AREAS, GENERAL:

| | |
|---|---|
| Storehouse, per floor (300 x 60) = | 18,000 sq. ft. |
| Storehouse, total for three stories = | 54,000 sq. ft. |
| Storehouse platform (470 x 92, over all) = | 25,240 sq. ft. |
| Power house (130 x 85) = | 11,050 sq. ft. |

#### WINDOW AREAS, LOCOMOTIVE SHOP BUILDING:

| | |
|---|---|
| Total area of wall, boiler shop side of building = | 23 260 sq.ft |
| Area of glass, boiler shop side of building = | 14,470 sq. ft. |
| Ratio of window area to area of wall = | 62.2 per cent. |
| Total area of wall, erecting shop side of building = | 27,740 sq. ft. |
| Area of glass, erecting shop side of building = | 17,280 sq. ft. |
| Ratio of window area to area of wall = | 62.3 per cent. |
| Total exterior area of entire building, exclusive of ends = | 211,260 sq. ft. |
| Total area of window glass in entire building, exclusive of ends = | 82,570 sq. ft. |
| Ratio of total area of window glass to total exterior area of building, exclusive of ends = | 39 per cent. |

### DISTANCES OF TRAVEL BETWEEN CENTERS OF SHOP DEPARTMENTS:

#### LOCOMOTIVE DEPARTMENT:

| | |
|---|---|
| Erecting shop to machine shop = | 85 ft. |
| Erecting shop to boiler and tank shop = | 175 ft. |
| Erecting shop to blacksmith shop = | 590 ft. |
| Erecting shop to storehouse = | 340 ft. |
| Totals = | 1,190 ft. |
| Machine shop to erecting shop = | 85 ft. |
| Machine shop to boiler and tank shop = | 90 ft. |
| Machine shop to blacksmith shop = | 570 ft. |
| Machine shop to storehouse = | 425 ft. |
| Totals = | 1,170 ft. |
| Boiler and tank shop to erecting shop = | 175 ft. |
| Boiler and tank shop to machine shop = | 90 ft. |
| Boiler and tank shop to blacksmith shop = | 620 ft. |
| Boiler and tank shop to storehouse = | 515 ft. |
| Totals = | 1,440 ft. |
| Blacksmith shop to erecting shop = | 590 ft. |
| Blacksmith shop to machine shop = | 570 ft. |
| Blacksmith shop to boiler and tank shop = | 660 ft. |
| Blacksmith shop to storehouse = | 800 ft. |
| Totals = | 2,620 ft. |
| Storehouse to erecting shop = | 340 ft. |
| Storehouse to machine shop = | 425 ft. |
| Storehouse to boiler and tank shop = | 515 ft. |
| Storehouse to blacksmith shop = | 800 ft. |
| Totals = | 2,080 ft. |

#### CAR DEPARTMENT:

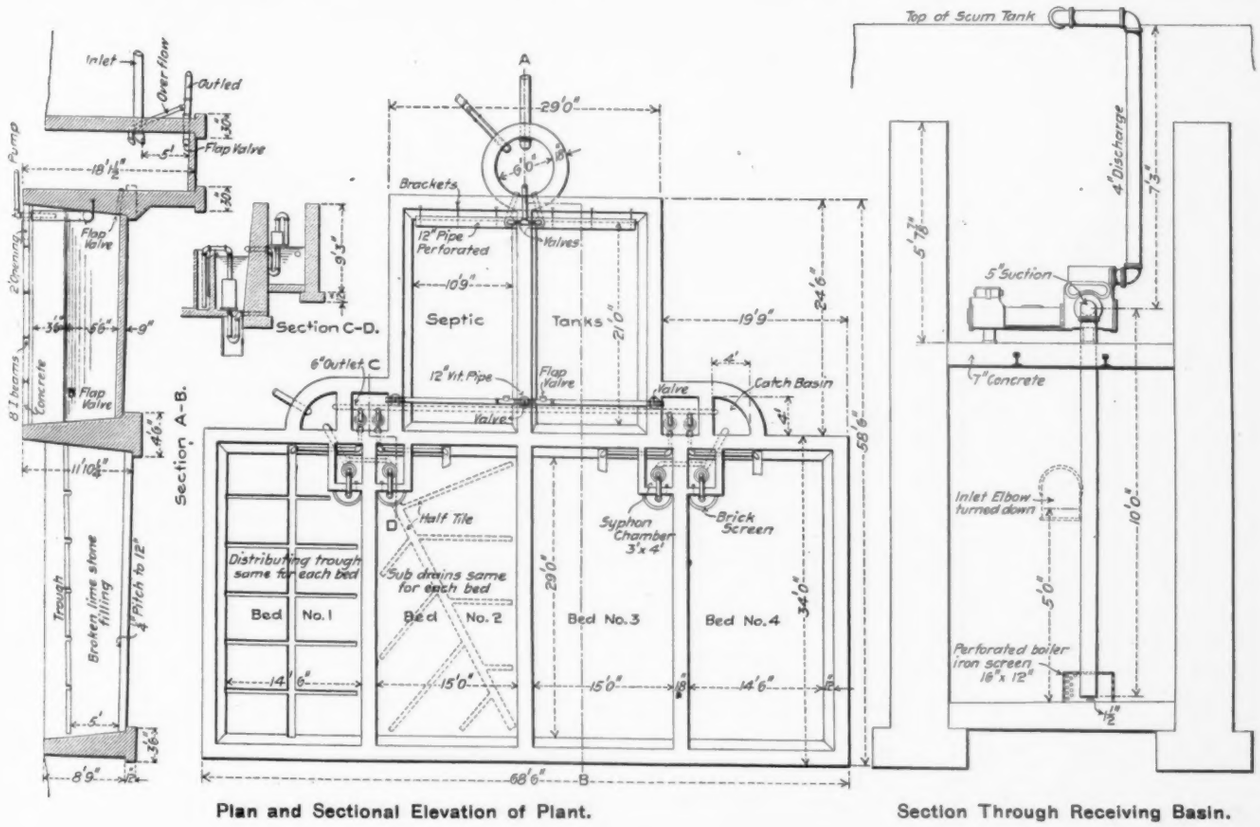
| | |
|---|---|
| Freight repair shop to wood mill = | 500 ft. |
| Freight repair shop to blacksmith shop = | 590 ft. |
| Freight repair shop to car machine shop = | 690 ft. |
| Freight repair shop to storage mounted wheel = | 1,025 ft. |
| Freight repair shop to storehouse = | 705 ft. |
| Freight repair shop to freight repair material storage = | 355 ft. |
| Totals = | 3,865 ft. |
| Coach shop to wood mill = | 690 ft. |
| Coach shop to cabinet shop = | 360 ft. |
| Coach shop to blacksmith shop = | 780 ft. |
| Coach shop to car machine shop = | 880 ft. |
| Coach shop to mounted wheel storage = | 1,210 ft. |
| Coach shop to storehouse = | 430 ft. |
| Coach shop to paint shop = | 240 ft. |
| Totals = | 4,590 ft. |
| Wood mill to freight repair shop = | 500 ft. |
| Wood mill to coach shop = | 690 ft. |
| Wood mill to cabinet shop = | 360 ft. |
| Wood mill to dry lumber shed = | 460 ft. |
| Wood mill to dry kiln = | 380 ft. |
| Totals = | 2,390 ft. |

### Drainage System.

Particular attention has been paid to the sanitary equipment of the Collinwood shops, thus necessitating a complete sewer system and means of sewage disposal. Lake Erie, which is the natural drainage for Collinwood, is lined at this point with beautiful summer residences, owing to which specially enacted legislation prohibits the discharge into it of sewage or other refuse liable to pollute the shore or cause unpleasant odors. For this reason a bacterial sewage disposal plant of a capacity of 40,000 gallons per day was decided upon and installed, which purifies the sewage and then discharges it to the lake.

The details of this disposal plant are presented in the accompanying drawing, which shows it in plan and sectional elevation, and also a sectional elevation of the receiving basin. The sewage from the shop sewer system flows into the receiving basin or circular section adjoining the septic tanks, which basin is provided with an overflow outlet and direct outlet for prevent agitation of the liquid and consequent interruption of the bacterial process. This process involves no "treatment" of the water. It merely offers an opportunity for the bacteria to act and purify it.

The liquid stands in the septic tank where the desired bacterial process of purification begins, the usual scum forming with the attendant reduction of foul matter in the sewage by the bacteria. Either one of the septic tanks, which have a reserve capacity 50 per cent. greater than will now be needed, may be used, valves being provided for all possible connections and flow. As the level of the liquid rises in the septic tanks it flows into one of the two catchbasins at the sides, which catchbasins are provided with automatic siphons for emptying their contents out into the contact beds, Nos. 1-4, when the level rises to a certain height. Each catchbasin has two siphons, each delivering into one of the two adjacent contact beds through a multi-ported trough for preventing rush of liquid and agitation.




Plan and Sectional Elevation of Plant. Section Through Receiving Basin.

Sewage Disposal Plant.

use in emergency only. The location of the plant did not permit of placing the various tanks at different levels for gravity flow from one to another, so the sewage is pumped from the catchbasin up into the septic tanks upon a higher level, from whence it flows by gravity into the contact beds beyond. For the pumping a duplex pump, operated by compressed air, is used, a float in the basin controlling the air-admission and operation of the pump. An air-driven pump, rather than an electrically-driven pump, was used, owing to the greater reliability expected from the former, as well as the probability of a more constant supply of air than of electricity; also the susceptibility of an electric motor to dampness, as would be inevitable in this work, counted against its use. The delivery from the pump, which branches through valves for feeding into either septic tank, is enlarged from 4 ins. in diameter to 12 ins. for a length at the end, which length of 12-in. pipe is perforated, to cause a quiet flow, to

The contact beds are filled with broken limestone, clean and free from dirt to prevent clogging, in contact with which the sewage stands for some time, to carry out to the best advantage the bacterial action started in the septic tanks. A medium size of broken stone is used for the filling, having 40 per cent. voids in the interstices. From the contact beds the sewage drains out, through open-jointed half tile on the bottom of the bed, to outlet catchbasins, which are also provided with automatic siphons intermittently delivering out into the lake. By the time the sewage is flushed out of the contact beds it is sufficiently purified so that there is absolutely no odor and almost no color; it is, in fact, almost pure enough for domestic use, showing that the process is carried further than is really necessary. One of the most important features of this plant is its entirely automatic action, the pump and siphons working automatically, which renders only occasional attendance necessary.

## NEW ALTERNATING-CURRENT SYSTEM FOR THE OPERATION OF ELECTRIC RAILWAYS.

A particularly interesting announcement has recently been made by the Westinghouse Electric and Manufacturing Co. in regard to the equipment of an important new interurban electric railway, which they have contracted to furnish. The rather startling statement is made that they are to equip the new 40-mile Washington, Baltimore & Annapolis Electric Railway with single-phase alternating-current apparatus throughout! It is claimed that a system of single-phase alternating-current operation has been devised which avoids the limitations inherent in polyphase induction motors, as also, of course, the disadvantages of the extra conductors necessary in polyphase systems, although very little definite information regarding the details of the system have as yet been given out.

It is safe to say that such a system as this is what street-railway engineers have been looking for ever since the existence of electric railway systems. The hitherto absolute necessity of feeding direct current to the car-motors has proved to be the greatest drawback to modern street-railway development. In the usual method of operating electric railways direct current is fed to the trolley line for the car motors, the current being usually generated as direct current for city lines and districts of heavy traffic; but for long-distance interurban roads the great cost of the copper in feeders is entirely prohibitive to direct-current distribution, so that alternating current is generated at high pressure and transmitted to numerous sub-stations, where it is transformed by means of transformers and rotary converters to direct current at the usual railway voltage—from 500 to 650 volts. The rotary converter sub-station has, however, always been an undesirable feature on account of the cost of the building and apparatus and the attendance required. In Europe the polyphase system using induction motors has been used to some extent, but it involves the use of two or three overhead wires, and, moreover, the characteristics of the induction motor in regard to its starting power and average efficiency in railway service are not good. Other systems which have been proposed involve the use of single-phase synchronous alternating motors upon the cars driving generators which, in turn, supply power to the motors on the axles. This, however, involves the placing of a sub-station upon the car itself, and so cannot be considered a great improvement over the ordinary alternating-current direct-current system.

Single-phase alternating current will be generated for this road in a main power-house located at Hyattsville by three 1,500-kilowatt single-phase Westinghouse generators, delivering current at 15,000 volts, and driven by cross-compound Hamilton-Corliss engines. Current will be distributed from the power-house at 15,000 volts to transformer stations located at suitable intervals along the line. These transformer stations will contain stationary alternating-current transformers only, with the necessary switches and fuses, but no moving machinery, thus not requiring the presence of an attendant. From these sub-stations current will be fed to the single trolley-wire line at 1,000 volts, the pressure of 1,000 volts which has been adopted not, however, being a necessary part of the system, as a much higher voltage could have been used if it had been deemed advisable.

The cars will probably be 60 feet in length, weighing about 50 tons each, and will be equipped with trucks designed for high speed. Each car is to be equipped with four motors, each of 100 horse-power, with which it is expected a normal speed of 40 to 45 miles can be attained and a speed of 60 miles when necessary. The motor, which is the novel part of the equipment and the key to the entire system, is a variable-speed motor having characteristics adapted to railway service and in all respects equal to the present direct-current railway motor. It has been developed and tested in severe service during the last few years by the Westinghouse Electric and Manufacturing Company, under the supervision of their assistant chief engineer, Mr. B. G. Lamme.

Although no definite information has been received from the Westinghouse Company regarding this interesting installation, it has been elsewhere learned that the system to be used is that of using series-wound motors of the direct-current type, adapted to alternating current by completely laminated magnetic circuits, including laminated field cores and pole pieces, together with other modifications necessary in the windings. It has long been known that direct-current motors thus adapted will run successfully on alternating current, but heretofore great difficulty has been encountered with sparking at the commutator, as well as low starting torque and low efficiency. It is said that this Westinghouse motor has largely overcome these difficulties, the sparking being greatly diminished and the power factor rendered high. If such is the case, and starting accelerations prove to be as satisfactory as with existing direct-current systems, the new system will undoubtedly meet with great favor. Several minor difficulties have yet to be encountered however, one of which, the large inductive drop in voltage sure to result from passing the return alternating current through the circuit of iron formed by the rails, bids fair to give considerable difficulty.

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"It may not be out of place here to refer to what appears to have been an oversight in planning the water-supply systems of the railroads in America, at least. It seems sometimes that the idea has been that a water tank or column in sight is as good as one at hand, and as a result locomotives are delayed near water stations until other locomotives are supplied with water. Large switching yards are provided with one or two cranes, usually near a short ashpit, and several times a day a line of locomotives may be seen near the water station, the crews awaiting their turns. There must be done just so much work, and just so much water must be used to do it, and it is cheaper to deliver the water in pipes to the locomotives than to run the locomotives to the water stations, if the stations are not conveniently located. With the cranes conveniently located in a switching yard, the locomotive tanks need not be of extreme capacity, and it is expensive to switch water backward and forward. The saving in cost of pipe and cranes is a false economy."—F. M. Whyte, in his paper before the Master Mechanics' Association.

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In discussing the cost of mechanical and hand stoking in *Engineering Magazine*, Mr. W. W. Christie says: "A full day's work for an able fireman is the shoveling of not more than 10 tons of coal in 12 hours, or about sufficient for 450 boiler horse power. If the same man is required to handle coal into hoppers for mechanical stokers, he could take care of two units of 500 horse power each, while if the coal was fed into the hoppers automatically he could take care of four such units, or 2,000 horse power. The cost of labor would thus be reduced in the proportion of 450 to 2,000, or about three-fourths, one man being able to do the work formerly requiring four. The time required for cleaning a fire under a mechaniaclly fired boiler is also said to be less than one-tenth that needed for similar work with hand-fired furnaces. * * * Apart from considerations of economy and of smoke prevention, the introduction of the mechanical stoker is to be advocated for the reason that it supersedes one of the most fatiguing and difficult kinds of work which has been undertaken by human effort. Even in land installations the work of firing boilers is hard and dirty, while on shipboard it has long been considered the heaviest and most exhausting work which can be performed. Of all labor-saving machinery, that which relieves human beings from the stoking of boilers should be welcomed, even if no commercial advantages should result."

**Improved Natural Lighting for Round-houses.**

## INCREASED LIGHT FOR ROUND-HOUSES.

Method of Wall Construction Permitting Larger Window Area.

By T. A. Lawes, Superintendent of Motive Power and Machinery, Chicago & Eastern Illinois Railroad.

At the last meeting of the American Railway Master Mechanics' Association, Mr. Forney said: "In past years I have had occasion to travel through the country and visit railroad shops in many places and it seems as if the designers of railroad shops always took the greatest pains to exclude daylight."

This criticism cannot be controverted. The writer has visited a number of shops on important roads, and has observed that all are poorly lighted. Railroad shops are in this important particular behind manufacturing shops. The Chicago Ship Building Company's machine shops at South Chicago, Ill., are models for imitation; with the exception of the monitor roof the sides and roof of their shop are of steel and glass, and, paradoxical as it may seem, the light inside of the shop is better than it is outside—due, no doubt, to reflection and the use of machinery painted white. This shop is a splendid example of what may be done to furnish adequate lighting. The erecting shop of the steam engineering buildings at the United States Navy Yard in New York City is also a fine example of a well lighted building.

The round-house is the shop building that should be designed with greatest possible window area. In busy times it is the most important shop, since it is then used as a repair-shop for the running repairs of engines, as well as for housing them also. Round-houses are as a rule miserably provided with light; each section usually has in the outside walls two windows, narrow and of small dimensions, and a few small windows above the doors in the inner circle. Work in the round-house must always be done promptly, but the mechanics are handicapped at the outset in being obliged to work with lamps in broad day light.

The accompanying view shows the outer wall of a proposed round-house, with a window arrangement which will increase the light entering 350 per cent. beyond that of our present round-houses. The roof trusses rest upon "Z"-bar built-up columns, which are enclosed, for fire-proofing, by brick-work. The bricks, however, carry none of the weight of the roof. The brickwork above the windows, and between pilasters, is carried by 6-in. I-beams, supported by the Z-bar columns. The roof and upper brickwork are wholly supported by the Z-bar columns, and the 6-in. I-beams serve only to tie the Z-bar columns together and to carry the small amount of brickwork above the windows. The top window sash is balanced by the lower sash, which affords in warm weather an excellent ventilation—far beyond anything now in use.

This drawing is furnished to show how the increased lighting may be accomplished; the stock excuse has been, when more window area was required, that the upper part of the brick wall between the pilasters would be weakened, but the plan submitted here will render such excuses void.

## ECONOMY OF STEAM TURBINES.

Superheated steam gives excellent results in steam turbines. Tests made by Messrs. Dean & Main on a 300 h. p. De Laval turbine at Trenton, N. J., showed that at full load, about 350 h. p., the steam consumption with saturated steam was 15.17 lbs. per h. p. With steam superheated 84 degs. F., the consumption was reduced to 13.94 lbs., a saving of 8.8 per cent. These figures are based on brake horse-power. A recent number of *Engineering Record* presented the results in full.

A noteworthy installation of turbines will soon be made in the equipment of the power house of the Cleveland, Elyria & Western Electric Railway. Two Westinghouse turbines will be direct connected to two 1,000-kw. 2-pole generators running at 1,500 revolutions per minute, furnishing alternating current at 400 volts and 25 cycles per second. The steam pressure will be 150 lbs. and the superheating will be 200 degs. The turbines will exhaust into condensers and a performance of 10.8 lbs. of steam per horse-power-hour is guaranteed. At one-half load the consumption is not to increase more than 15 per cent. These turbines, described in a recent number of *Engineering Magazine*, are novel in that the steam expands in two chambers successively, with a reheater between them. By using these engines the space available in the power house can be made to yield 5,000 kw., as against 2,000 for reciprocating engines.

Car for the Interborough Rapid Transit Railway, New York City.

## CARS FOR THE INTERBOROUGH RAPID TRANSIT RAILWAY, NEW YORK CITY.

Mr. George Gibbs, Consulting Engineer for the Interborough Rapid Transit Company, New York City, has employed a novel and interesting method of deciding upon the minor details of the construction of the standard cars of that road. The structure of the subway determined the length and cross section of the cars and the high speeds in a double and four track tunnel necessitated vestibules. These features being established, two sample cars have been built by the Wason Manufacturing Company, Springfield, Mass. They are fitted up with various fixtures and interior arrangements, both having automatic couplers, continuous platforms, platform buffers and electric heaters. These cars are to be completely equipped electrically as well as otherwise, and will be run upon the Long Island Railroad, which has a portion of its line equipped with the third rail. Every feature will be thoroughly tested before the equipment is ordered, and experience with these sample cars will enable the officers to contract for the entire equipment and make it standard without changes.

These engravings show side, end and interior views of one of the cars. It will be noticed that the sides have an inward slope from the window seats to the roof. This was necessary in order to secure the maximum space for the passengers, and yet come within the limiting curve clearances; otherwise the appearance and arrangements closely resemble those of elevated equipment, except that there is everywhere evidence of stronger construction. The following comparison is interesting:

Comparisons of Car Dimensions.

| | Interborough. | Manhattan. |
|---|---|---|
| Length over platforms | 50 feet 1 inch | 47 feet 1 inch. |
| Length over car body | 42 " 7 inches. | 39 " 10 inches. |
| Length center of bolsters | 36 " 0 " | 33 " 2 " |
| Width over window stools | 8 " 11⅝ " | 8 " 9 " |
| Width over sheathing | 8 " 9¾ " | 8 " 7 " |
| Width over deck eaves moulding | 8 " 5 " | 8 " 9½ " |
| Height top of rail, center draw-bar | 2 " 5 " | 2 " 5 " |
| Height top of rail to under sills | 3 " 1⅛ " | 3 " 3¼ " |
| Height top of rail over platform | 3 " 8 " | 3 " 9 " |
| Height top of rail over roof | 12 " 0 " | 12 " 10½ " |

There are four longitudinal sills of composite construction. The centre sills are 5-in. I beams, sandwiched between two 3 x 5 in. timbers, and the side sills are 6-in. steel channels, to which an outside strip of 3¾ x 7 ins., and an inside strip 3¼ x 6 in. are fitted. The sills extend through the platforms, terminating in steel castings, to which the platform end sills are secured. The sills are braced by centre cross trussing between the needle beams. The platform end sills are 6-in. channels, fitted with ¼-in. steel, anti-telescoping plates extending 15 ins. toward the rear and the full width of the platform below the sills. The side framing of the car bodies is white ash, doubly braced and heavily trussed.

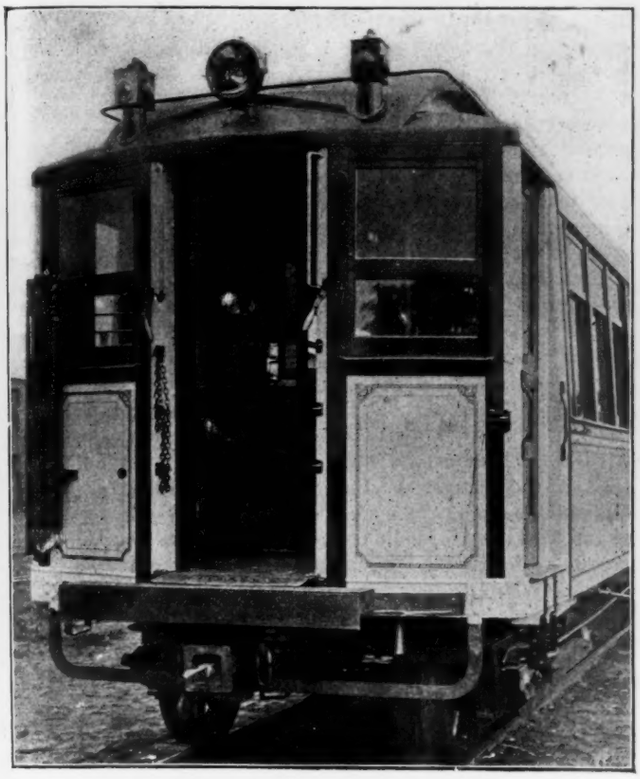
The platform posts are composite, with steel bars sandwiched between substantial white ash posts at the corners and centre of the vestibule platform. These posts are bolted to the steel longitudinal sills, also to the anti-telescoping plate below the floor, and to the hood reinforcement, which is a heavy steel angle reaching in one piece from plate to plate and extending back 6 ft. into the car body on each side. In case of an accident in which one platform rises above the other, 8 sq. ins. of metal must be sheared off before other damage can be done.

The car illustrated has vestibule doors of the Gibbs type, supported from above, and sliding into pockets in the side framing without taking up room required for the passengers. The other car is fitted with the Gold, Pitt, Duner and Gibbs doors, for the purpose of making a comparison of their relative merits. The end vestibule door is arranged so that it may close up the passage between the centre vestibule posts or it may form a closed compartment on the vestibule for the motorman. The end view shows the levers for operating the Gibbs doors.

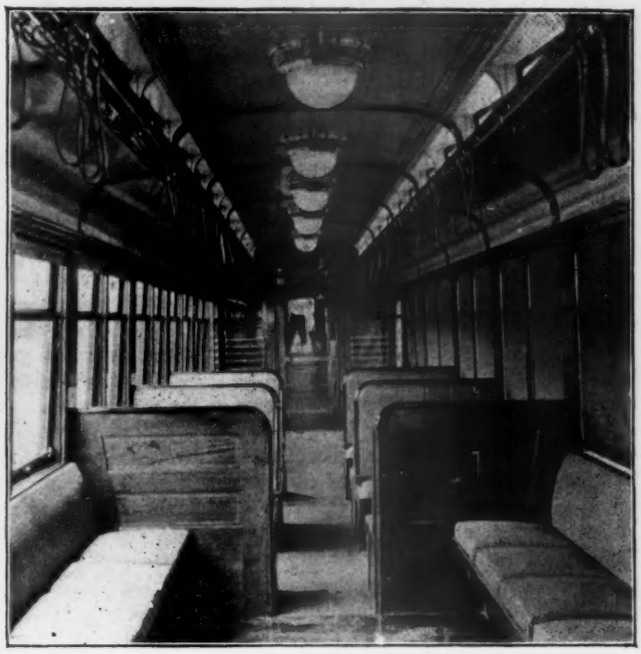
Both cars have double floors, with fire-felt sandwiched between the layers. In order to secure absolute protection against fire from the wiring, a lining of ¼-in. "transite" board is secured as a lining underneath the sills and bridging. In this way the wiring is kept away from all wood; furthermore, the motor circuits do not enter the cars at all, and the fuses and blow-outs will be enclosed in fireproof boxes in the motorman's compartment outside of the car. In this there is a lesson for all designers of electric equipment.

One car has the ordinary clerestory roof and the other the half empire form, with light-colored ceiling. One has cluster lights on the upper deck ceiling, and the other has single incandescent lamps on the upper and side deck ceilings. In one car the lower windows are stationary and the upper ones raise; this arrangement will undoubtedly be adopted, though the size of the glass may be changed. The floor covering presents a problem. Cocoa mats, linoleum and maple strips are being considered. For sanitary reasons the maple strips are likely to be adopted, and the spaces under the seats will probably be boxed in as shown in the car illustrated.

New difficulties in the way of reverse curves preclude the



End View, Showing Platform.



Interior View.

use of the ordinary platform of either the Pullman or Standard types. With a view of meeting this problem a new experimental continuous platform buffer has been developed for these cars by the Standard Coupler Company, and the end view shows one of them. This will be tried in service, and whether adopted or not, is exceedingly interesting. The long plate buffer shown in the engraving is carried on the drawbar, and moves laterally with it, the weight being carried on the flange of an angle curved to fit the under side of the platform end sill.

The electrical equipment, including the trucks, has not yet been decided upon, but it is understood that each motor car will have two motors of 200 h. p. each, and that each local train of five cars will have three motor cars. In the express trains, five out of eight cars will be motor cars. When the decisions with reference to the details have been made, and the working drawings completed, the construction will be placed on record in this journal.

## RELIABILITY OF GAS ENGINES.

Confidence in the gas engine for important service is increasing to an extent which will surprise those who have been accustomed to consider it an unreliable and uncertain motor. The reason for this feeling is to be traced to the claims of manufacturers to the effect that such engines do not require expert attention. If this was ever true of the smaller sizes it certainly does not apply to larger ones, and it is found necessary, as in the case of all classes of machinery, to give them suitable attention. It is well known that a 65 horse-power Westinghouse gas engine was run continuously for 128 days at the works of the Consolidated Gas Company in New York some time ago, the only stoppages in all this time aggregating 34 hours.

According to an interesting article in "Engineering News," an extensive installation of large gas engines is now under way in Philadelphia in connection with the fire service in the business district of that city, where the requirements are unusually exacting. The plant will contain ten 280 horse-power, 18 by 22-inch Westinghouse 3-cylinder single acting gas engines, though but seven will be at present installed. These engines will be direct connected by gearing to 1,200 gallons, triplex, double action piston pumps working against a pressure of 300 pounds per square inch, and discharging into a 20-inch main. Two 125 horse-power 13 by 14-inch Westinghouse 3-cylinder gas engines, will also form part of this equipment and will be geared to smaller pumps through friction clutches. These engines will also supply the electric igniters and drive air compressors to furnish air under pressure to start the larger engines.

The gas engine was selected for this work because of the following requirements, which it fulfills better than any other form of power: Readiness for full duty load within a period of one minute from the time of the alarm signal, absolute continuity of operation, high economy of floor space, economy of fuel, simplicity of construction and care and rapidity of repairs. For intermittent service this power is specially well adapted because it is not necessary to maintain steam pressure always in readiness for use and when the engines stop the fuel expense stops altogether. A better tribute to the gas engine as a reliable motor could hardly be imagined. Such an installation will doubtless be well supplied with spare parts for the engines, and this will dispose of the question of repairs very satisfactorily.

**The use of liquid fuel on board ship has been unsuccessful to a considerable extent on account of the rapid burning out of some part of the furnace of boiler. This may have been due to the use of burners or atomizers too large for the purpose. In one case where a single large burner was used, the combustion was by no means completed in the firebox, but continued through the boiler flues and on into the base of the smoke stack. The heat generated in the smoke stack was so great as to burn out its lower ring. In the first vessel launched by the New York Shipbuilding Company, oil burners were installed in small units, five small burners being used in each furnace. They are set well out in front of the boiler in order to leave plenty of space for combustion in the firebox.—Engineering Record.**

## STEEL RAILS: SPECIFICATIONS.

By Robert Job, Chemist of the Philadelphia & Reading Railway Company.

Freedom from fracture and slow wear or distortion under heavy traffic are essential qualities in a satisfactory rail, and call for both strength and ductility in the steel, and these, in turn, are regulated partly by composition and partly by method of manufacture. Safety is dependent largely upon freedom from brittleness, and such condition is proved by ability to withstand the drop test. Slowness of wear, on the other hand, is not to any great extent indicated by the result of the drop test.

It is well known that, in general, with a given composition, strength and ductility and service durability in a given piece of steel increase inversely with the size of the granular structure, and that fine granular form is secured by thorough working of the steel down to the critical point. From this it might be thought that a rail finished at a rather high temperature, say at a bright yellow color, and therefore having a relatively coarse granular structure, would be fractured by the drop of 2,000 lbs. falling twenty or twenty-five feet. We have found, however, after investigating a large number of rails, that coarse structure in itself does not result in fracture under the drop, provided that the steel is sound and solid. At first thought it would appear that all steel which does not contain piping or similar defects is solid, but upon examination after polishing and etching, numerous small cavities and also particles of slag and oxide may be found, and it is these which break up the continuity of the steel and generally cause failure due to brittleness. Unsound condition of this character may be due to overheating and burning, whereby thin films of oxides are formed in the steel, rendering it exceedingly fragile, or it may be caused by overblowing or by failure properly to settle. In any case, it is unquestioned proof of defective manufacture, and can be guarded against at the mill by proper practice. Steel of this type shows a marked falling-off from the standard in both tensile strength and ductility, and in service tends to fracture in the track upon exposure to sudden changes in temperature.

Rails which, though having coarse structure, still pass the drop test, obviously have greater strength and toughness, and this has been found due to comparative freedom from the unsoundness mentioned above, and in rails of a given composition we have never found a case where steel which passed the drop test contained any appreciable proportion of this enclosed foreign matter and gas, especially near the surface.

Unfortunately, it is a matter of universal experience that these solid but coarse-grained rails give relatively poor service, wearing far more rapidly and having far greater liability to fracture than other rails of the same composition which also pass the drop test, but which have a relatively fine granular form. The question thus brought before every consumer is how to distinguish in a definite, practical manner between the two forms of structure and compel adherence by the mill to the finer form. The microscope, of course, shows the condition and tells the story at a glance, but this can hardly be used at the mill by an inspector whose time is well occupied in other ways, and a simpler method is therefore essential.

As stated above, fine granular form is merely an index of the method of treatment of the steel, and shows that thorough working has continued well down toward the critical point. Fine structure might, of course, be obtained by annealing the rail after letting it cool below the critical point, but this practice is not ordinarily followed.

It is a matter of common knowledge that metals expand as the temperature increases, and several years ago Mr. William H. Webster suggested that this property might be utilized in a practical manner by specifying that a rail of given length at the ordinary temperature should not exceed a definite length when cut by the hot saws immediately after the last pass of the rolls. It was found, however, that this procedure might not result in fine granular form throughout the rail, since the steel might be run at a high temperature through all the passes except the last, and there be held while cooling—and crystallizing—until at a temperature low enough to meet the shrinkage requirement, then receiving a reduction in the last pass too slight to work the steel to the center of the rail, and thus merely breaking up the coarse-grained structure near the surface, but having little or no effect upon that beneath. What is needed is, obviously, to complete the rolling in the shortest time practicable after reaching the point at which the rolls do not work the steel clear to its center, and with such practice to stipulate that the length between the hot saws shall not exceed a certain definite amount. The duty of the inspector is thus to see that rapid rolling and sawing are maintained and to see that the specified distance between the hot saws is not exceeded.

Under the old system which produced rapid-wearing, coarse-grained rails, the saws were spaced at about 7½ ins. in excess of the 30-ft. length, to allow for shrinkage in cooling to the normal temperature. Better practice, which produced better wearing rails, reduced this to 6¼ ins., and it is found perfectly possible to-day at the modern mill to keep within a 5¾-in. limit, with our rapid rolling requirement, a practice which prevents possibility of coarse granular structure. In our specifications we place our maximum at 6 ins., in order to avoid controversy, but we find it practicable, as stated above, to keep well within this figure.

From the foregoing it is evident that to secure a safe, durable rail, the drop test is essential, and also that there must be careful oversight of the process of manufacture.

A good deal of discussion has arisen as to the number of drop tests which are necessary to ensure thorough safety. The best practice, as we consider it, is to make a drop test upon one rail built from each heat, and in case of failure to take two more butts from other ingots in the same heat, the rail from the top of an ingot being taken in each case, and the result of the majority determining the acceptance or rejection of the heat. In some cases, where the condition of the steel is seriously defective, a series of heats may fail entirely, excepting, perhaps, a single one, and in such a case we retain the right to test another butt from that heat. In case of failure then, a third butt is tested, and decides the disposition of the heat.

Objection has been made that this test of every heat would delay the rolling and block the output of the mill, but in tests of many thousands of tons of rails under this practice we have never had the least difficulty in keeping well ahead of the work and in avoiding delay.

In process of manufacture it will be noted that no mention has been made as to whether the direct process or the use of reheated blooms is desired. Under the usual mill practice there can be no question but that the former will give the more satisfactory results, owing to the difficulty in maintaining the reheating furnace at a suitable temperature and in finishing with rapid rolling at the temperature specified. At the same time, there is no inherent reason why the reheating process should not meet the requirements, and if this can be effected by careful arrangement and method we feel that the product should be as satisfactory as that produced by direct rolling, provided, of course, that the reduction of the bloom after the reheating furnace is sufficient to work the steel thoroughly to the center.

Up to this point we have practically ignored the matter of composition, not because it is unessential, but because steel of the very best composition may be completely ruined by failure to observe correct rolling methods. Instance after instance has come under our observation of service failure of rails the composition of which has been within perfectly

satisfactory limits. The whole difficulty in each case was found to be a result of faulty mill methods. Present loads and speeds demand a high degree of stiffness in the rails, and this necessitates a fairly high proportion of carbon, and our regular practice for 90-lb. rails averages about 0.58 per cent. carbon, which, with the other elements, and with mill practice as specified, results in a strong, tough and fairly fine-grained rail, which seldom fails under a drop test of 2,000 lbs. falling 23 ft., the butt being 3 ft. between the supports.

In the matter of cropping, we have preferred not to specify a definite amount or proportion, but to work out the practice found desirable at each mill.

In length, the old standard of 30-ft. lengths is temporarily retained, though different lengths are ordered as desired. We are confident, however, that before long the practice of the mills will have changed materially, and that a standard of at least 45-ft. lengths will be adopted generally by the railroads.

In drawing up specifications we have taken those of the American Society for Testing Materials as a basis, raising its standard to that proved most desirable by our service results.

## PHILADELPHIA & READING RAILWAY COMPANY.

### SPECIFICATIONS FOR STEEL RAILS.

1—a.—The entire process of manufacture and testing shall be in accordance with the best standard practice and it is especially desired that thorough working of the steel in the rolls shall not cease until the temperature is as near as practicable to the recalescent point, or to about a low red heat.

b.—The temperature of the ingot or bloom shall be such that with rapid rolling and without holding before or in the finishing passes or subsequently and without artificial cooling after leaving the last pass the distance between hot saws shall not exceed 30 ft. 6 ins. for a 30-ft. rail, or a proportionate distance for other lengths.

c.—The amount of cropping shall be sufficient to ensure freedom from piping and injurious segregation.

d.—Ingots shall be kept in a vertical position in soaking pits.

e.—Bled ingots shall not be used.

2—Rails of various weights per yard specified below shall conform to the following limits in chemical composition:

| | 60 to 69 | 70 to 79 | 80 to 89 | 90 to 100 |
|---|---|---|---|---|
| Carbon ..... | .40—.50 | .43 to .53 | .46—.56 | .53—.63 |
| Phosphorus shall not exceed..... | .10 | .10 | .10 | .10 |
| Silicon shall not exceed ..... | .20 | .20 | .20 | .20 |
| Manganese ..... | .70—1.00 | .75—1.05 | .80—1.10 | .80—1.20 |

3—Drop Test.

One rail butt, at least 4 ft. long and not exceeding 6 ft., shall be taken from the top of an ingot from each blow and placed on skids to cool, and the blow number stamped upon it. When cool it shall be placed either head or base upwards, or upon the side, on solid iron or steel supports, 3 ft. between centers, and shall be subjected to the following impact test under a free falling weight, as specified in Section 4.

| Weight of Rail. Lbs. per yard. | Height of Drop. |
|---|---|
| Up to and including 70 lbs. | 18 ft. |
| All heavier than 70 lbs. | 23 ft. |

If any rail break when subjected to the drop test two additional tests will be made upon other rails selected by the Inspector from the same blow and if either of these fail, all the rails of the blow represented will be rejected; but if both the additional test pieces meet the requirements, all the rails of that blow will be accepted. If desired by the Inspector, two rail butts may be taken from each blow for the drop test, and if either of these fail, a third shall be selected by him, and fracture of the third will cause rejection of all rails of that blow.

4—Drop Test Machine.

The drop testing machine shall have a tup of 2,000 lbs. weight, the striking face of which shall have radius of not more than 5 ins., and the test rail shall be placed upon solid supports as specified. The anvil block shall weigh at least 20,000 lbs., and the supports shall be a part of, or firmly secured to, the anvil.

If the drop test machine differs in any respect from the above standard, inspection shall be made by this company, and rolling shall not be begun until approval has been given.

5—The manufacturer shall furnish the Inspector daily with carbon and manganese determinations of each blow, and a complete average chemical analysis of the blows of each day and night turn, the drillings being taken from small test ingots.

6—Section.

Unless otherwise specified, the section of rail shall be the American Standard specified by the American Society of Civil Engineers, and shall conform as accurately as possible to the template furnished by the Railway Company, consistent with paragraph No. 9 relative to specified weight. A variation in height of 1-64 in. less, and 1-32 in. more than that specified will be permitted. A perfect fit of the splice bars shall, however, be maintained at all times.

7—The rails must be smooth on the heads and bases free from all mechanical flaws, seams, and injurious defects, and must be sawed square at the ends, and entirely free from swells in the center of the head or on top of the flanges of the base.

The burrs made by the saws shall be filed and chipped off carefully, particularly under the head and top of flange, to insure a proper fit of the splice bars.

8—Cold Straightening.

The rails must be straight in all directions, as to both surface and line, without twists, waves or kinks, particular attention being given to having the ends without kinks or drops.

Rails shall be straightened while cold, and shall be absolutely free from "gag" marks.

The distance apart of the supports in straightening press must be suitable for the stiffness and section of the rail.

9—Weight.

The weight of rails shall be maintained as nearly as possible after complying with paragraph No. 6 to that specified in contract. A variation of one-half of one per cent. for an entire order will be allowed. Rails shall be accepted and paid for according to actual weight.

10—Length.

The standard lengths of rails shall be 30 ft. Ten per cent. of an entire order will be accepted in shorter lengths varying by even feet down to 24 ft.

A variation of ¼ in. in length from that specified will be allowed.

11—Drilling.

Drilling for bolts shall be in strict conformity with the blue prints attached or the dimensions given herewith and all holes must be accurate in every respect, and finished without burrs.

12—The name of the maker and the month and year of manufacture shall be rolled in raised letters on the side of the web, and the number of the blow shall be stamped distinctly thereupon in at least two places not subsequently covered by the splice plates. The rail from the top of each ingot shall also be stamped "A," the second rail "B," the third rail "C," the fourth rail "D," and the fifth rail "E."

13—Inspectors of this Company shall have free entry to the works of the manufacturer at all times when a contract is being filled.

All tests and inspections shall be made at the place of manufacture prior to shipment, but the Inspector may obtain drillings from test ingots, and subsequent analysis must conform to the limits specified.

14—No. 2 rails in amount not exceeding that specified in contract will be accepted.

Rails which possess any physical defect or for any other cause are not suitable for first quality, but which have no injurious defects, shall be considered as No. 2 Rails, and shall be painted red on the ends. Rails rejected under the drop test will not be accepted as No. 2 Rails.

15—Rails must be handled during manufacture and loading in such manner as not to bruise the flanges or cause other injury.

16—All rails which fail in service owing to defective manufacture or to improper handling at the mill, must be replaced free of cost.

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The Atchison, Topeka & Santa Fe has recently purchased a large tract, embracing about 1,500 acres, in the Kern River petroleum districts. This road is satisfied that crude petroleum is to be the fuel of the Pacific coast, and purchased the entire possessions of the Petroleum Development Company, of California, which will give a fuel supply for the Santa Fe lines from San Francisco to Seligman, Arizona—832 miles—for an indefinite period.

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## EDITORIAL ANNOUNCEMENTS.

**Advertisements.**—*Nothing will be inserted in this journal for pay,* EXCEPT IN THE ADVERTISING PAGES. *The reading pages will contain only such matter as we consider of interest to our readers.*

**Contributions.**—*Articles relating to railway rolling stock construction and management and kindred topics, by those who are practically acquainted with these subjects, are specially desired. Also early notices of official changes, and additions of new equipment for the road or the shop, by purchase or construction.*

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## THE COLLINWOOD SHOPS.

Railroad shops in which there is so much to commend and so little to criticise have seldom, if ever, been built before. The first view of the exterior of this plant is impressive of size, solidity and convenience. Further examination confirms this impression and reveals a remarkable combination of factors selected with one purpose and admirably arranged to serve it—the business principle of maintaining locomotives and cars upon a commercial basis. It is a sensible, business-like shop plant, containing no fads or experiments, and represents a judicious expenditure of a large sum. It is safe to say that as a plant it will long stand a monument to the business sagacity and engineering ability of the men who created it and as an example of unreserved co-operation of officers of different departments who must come together in problems of this character. The thoroughness with which the details were worked out by the officers of the road and the consulting engineer surpasses anything of the kind we have ever seen. It is a pleasure to describe an exceptional result so harmoniously attained, and sufficient space will be given to place the plant on record in a worthy manner.

## HEAT TREATMENT OF STEEL.

Steel rails which would satisfy specified chemical and physical requirements and meet the approval of inspectors as to finish and section, were formerly accepted as entirely satisfactory in spite of the fact that every one knew that the use of larger sections was not accompanied by satisfactory wear. In fact, some of the light rails of twenty years ago have given better wear than heavier ones of quite recent date. In this issue is printed an important contribution on the subject, which has a bearing on many steel products other than rails. Mr. Job has made a painstaking study of steel rails with the aid of the microscope, combined with careful observation of mill practice, a study of chemical analysis, physical tests and records of service. He gives an important place to chemical and physical requirements, but goes much further and controls the treatment of the steel in finishing. Mr. Job's work confirms that of the best known investigators in this field, and his opinions are presented with confidence. Attention should be directed also to the factor of heat treatment in other steel products.

In steel forgings of all kinds the treatment while hot unquestionably affects the results, and is as important as in connection with rails. Those who are engaged in drafting specifications of steel of any kind, which is worked at high temperatures, should give most careful consideration to this article.

## THE SHOP AS A SCHOOL.

When young technical school graduates are about to enter practical work they are often wisely told that they should consider their period of studying as only beginning. They are also often told that the shop is a school in which to complete their education. It is a school in the broadest sense and, to those who succeed, all life is a period of continuous study and instruction. But the attitude of the young man entering practical work toward that work may be vitally influenced by his understanding of the kind of school he is to attend. With the hope of offering a valuable suggestion, a comparison will be drawn between two imaginary young men, who are supposed to have been graduated from the same technical school and to have begun a career in the motive power department of the same railroad. Both are bright earnest young men, ambitious and sensible and both are naturally in a hurry to "get on in the world."

No. 1 has corresponded with the superintendent of motive power and is accepted as a special apprentice. An attractive course of three years is offered him and he knows that he will be moved about at more or less regular intervals and cover the work of the entire department in that time. He begins work and does very well. He learns a great deal and covers a wide range of work in three years. He has a good general view of the motive power problem at the end of the time and is ready to apply what he knows. The shop has been to him a school of instruction and he ought to be prepared for a position of responsibility if he has profited by the opportunity he has had. During this time he has been known all over the shop as a man from whom much is expected and he has been given special privileges because of his education. But if he is of the right sort he will have gained the confidence of the men and the officers and he should have a good general idea of how the department should be managed.

No. 2 is also accepted as a special apprentice, but after thoughtful consideration makes up his mind to make an independent start. The roundhouse seems to offer the best opportunity for experience and he goes to the foreman and asks for a job. On being questioned the young man cannot tell what he can do. He is put into the boiler washing gang. He does not like this work, but he gets some good ideas and valuable experience. In connection with this work he occasionally helps on boiler and other repairs and gradually obtains a view of the whole roundhouse and its importance. He sees a way to improve the method of handling the boiler washing and asks for an opportunity to try it. He is soon in charge of the boiler washing gang and his experience as an executive begins. From emergency work in the roundhouse, the next step is to the erecting shop, and he goes to the general foreman and again asks for a job, this time as a helper. The men in the gang and

the foreman are prejudiced against him and haze him. This bothers him until he determines to win their friendship. In a short time he has it, and the hazing is replaced by respect and friendliness, which, when accorded by shop men, is a valuable possession. He boards with the men, eats at their table and really lives among them. He not only understands their work, but knows their surroundings and understands them thoroughly, because he is one of them. Soon the gang foreman turns one of the other helpers over to this young man and the management of men begins again. In less than a year this student is the leading man in the gang and next becomes a gang boss. After making a success of this position he sacrifices it to enter the machine shop as a machine hand and is given a set of eccentric straps to bore. This happens to be an emergency and the foreman takes advantage of the young man to discourage him. The eccentric straps are bored, however, and are right, though the method is clumsy. He had no help or instruction in this, but gets on infinitely better without, because he is obliged to get the results and it is necessary to win the confidence of this shop also or he cannot stay in it. He remains here until he is offered the position of assistant foreman. After handling this well he leaves the shop and learns to fire a locomotive in the regular way. He is firing in freight service at the end of three years and is holding his own in the pool.

The question is: Which of these young men, of equal ability and equal mental and physical skill, is more likely to be selected as foreman of an important roundhouse or master mechanic of a small division? Both of them considered the shop as a school, but their points of view were entirely different. The shop is modified to receive the first, and to a certain extent the officers of the road did homage to his education. His view of the shop is not the view taken by the men. There is an important element of the knowledge of men, to which the so-called "practical men," who fill so many important positions to-day, owe their success, which he cannot obtain. He may, perhaps, get along without it, but the lack of it is a handicap. On the other hand the second considers the shop as a plain shop. It is an organization in which he is to find his place at once. His position depends upon himself alone and he is obliged to make his way from the very beginning.

The following question is left to the reader: Which of these young men is better qualified to meet the emergencies of railroad service, where experience, knowledge and steady-headedness are so vitally necessary, and which of them is probably the better able to understand the difficulties and to meet them, including the management of men?

## COMPARISON OF LOCOMOTIVES.

Locomotive development has reached a stage requiring frequent comparisons of the principal factors. This is particularly necessary in getting up new designs and in making any sort of study of the factors going to make up the capacity for sustained power.

There is no lack of methods or bases for comparison. In 1897 Mr. Henderson suggested the ratio between heating surface and cylinder volume as a good basis, and at the recent convention Mr. Gaines proposed the ratio of heating surface to horse-power, and Mr. Waitt suggested the relation between the heating surface and the weight on drivers. Each of these has its advocates and each has been criticised. It is natural that those who use any particular method of comparison should employ it in their estimate of the value of each new design as it appears. But while each method may have its good points, a uniform method is desirable in order that those who are most interested in the subject may, so to speak, talk in the same language. It is not so necessary to have the best method of comparison as it is to secure uniformity.

Mr. Fry presents a new method in his article in this issue, and it has strong claims for attention, as it embraces all of the necessary factors, and its terms include none which are taken or calculated specially for the purpose of comparison. He introduces the steam pressure, cylinder power, driving-wheel diameter and heating surface in a single ratio, involving the tractive power, size of driving wheels and heating surface, all of which are prominent factors in any consideration of a locomotive design.

This matter is attracting interested attention and is the subject of considerable correspondence among the younger locomotive men. It is hoped that the discussion will lead to a careful consideration of the whole question by the Master Mechanics' Association and the adoption of a uniform plan to be generally used. Such a course may be expected to result in a considerable improvement in the American locomotive, for it would unquestionably lead to more frequent comparison and a better knowledge of the problem of securing the maximum possible amount of sustained capacity, and this is what is wanted.

## THE RELATION BETWEEN HEATING SURFACE AND CYLINDER POWER.

A Measure for the Steaming Capacity of Locomotives.

By Lawford H. Fry.

The proper relation of boiler capacity to cylinder power is of such vital importance in locomotive design that it is remarkable that there is no generally accepted standard for its measurement. A number of different ratios have been proposed as a basis of measurement, but none has been universally adopted. The purpose of the present paper is to advocate the use of a method which will be shown to be extremely simple and at the same time perfectly accurate. It will be shown that the steaming capacity of a locomotive is inversely proportional to the quantity obtained by dividing the maximum cylinder tractive effort by the total heating surface area, and multiplying the result by the driving-wheel diameter. In this article the steaming capacity factor thus obtained will be referred to as "BD," so that

$$BD = \frac{\text{max. cylinder tractive effort}}{\text{total heating surface}} \times \text{driving-wheel diameter.}$$

In comparison with other quantities and ratios which have been suggested for the same purpose, BD has the advantage of being determined by the least possible amount of calculation, and in this calculation only such quantities are used as are required for other purposes in an investigation of the locomotive. Various systems for measuring the relation between boiler capacity and cylinder power have been suggested before the Master Mechanics' Association, the more important being:

1. That suggested by Mr. George R. Henderson and endorsed by the Association in 1897. In this the ratio of heating surface to cylinder volume is taken as a measure of the steaming capacity. This gives accurate results in the comparison of locomotives having the same working pressure, but if two engines have 19 x 26-in. cylinders, and one is worked at 180 and the other at 200 pounds boiler pressure, with the same cut-off and speed, the engine with the higher pressure will develop about 11 per cent. more power, and should therefore have a correspondingly greater boiler capacity. This method also requires the calculation of, or the use of, a table of cylinder volumes, which is unnecessary in the determination of BD.

2. That suggested by Mr. A. M. Waitt before the Association this year of the ratio of weight on driving wheels to heating surface. Figures can be obtained on this basis to give the proper relation between heating surface

and adhesive weight for a given service; but as the heating surface utilizes the adhesive weight through the medium of the cylinders, it appears more logical to determine separately the proper relation between boilers and cylinders, and between cylinders and adhesive weight. The use of this method would also be complicated by the introduction of traction increasers.

3. That suggested by Mr. Gaines in his paper before the Association this year, of determining the ratio of heating surface to maximum horse-power (at as many miles per hour as the driving-wheel diameter has inches). This ratio is a proper measure of the steaming capacity of the locomotive, but to find it one must calculate the cylinder horse-power at the above speed (336 revolutions per minute), which is a quantity not otherwise valuable, as unless designed for very high speed the boiler will not be capable of maintaining full cylinder power at this speed.

In finding the factor BD the only preliminary calculation is the determination of the maximum tractive effort at slow speed, a quantity which is always required in any examination of a locomotive. And further, the algebraic analysis given below shows that BD is an accurate measure of the steaming capacity, and that it is adaptable to all conditions of service. It will be shown that

$$BD = \frac{2370\ b}{c\ r}$$

where b measures the maximum rate of evaporation,
c is the length of cut-off in per cent. of stroke,
r is the number of revolutions per minute;
so that for any given conditions of service the proper value of BD—that is, the proper relation between boiler capacity and cylinder power—may be determined.

BD is *inversely* proportional to the steaming power of the locomotive, so that to develop full cylinder power at high speeds a locomotive must show a low value of BD, while a high value of BD indicates a low steaming capacity. These conclusions, arrived at from theoretical premises, are well sustained by figures from actual practice, as may be seen from the accompanying tables. These represent figures obtained from 79 locomotives constructed in the last three years. The figures have not been selected to produce a special result, but are from locomotives which appear to represent modern American practice. The dimensions are taken from the technical papers for the years 1900, 1901 and 1902, and from the "Records of Recent Construction of the Baldwin Locomotive Works."

Table I.

| Type. | Number of Locomotives. | Values of BD. Min. | Max. | Mean. |
|---|---|---|---|---|
| Prairie | 3 | 541 | 594 | 570 |
| Atlantic | 14 | 566 | 741 | 648 |
| American | 8 | 624 | 829 | 712 |
| Ten-wheeler | 25 | 646 | 900 | 753 |
| Mogul | 5 | 731 | 805 | 772 |
| Consolidation | 24 | 685 | 946 | 8 6 |

Table II.

| Service. | Number of Locomotives. | Mean Value BD. |
|---|---|---|
| High Speed | 25 | 635 |
| Medium Speed | 25 | 753 |
| Low Speed | 29 | 809 |

In Table I. the locomotives have been grouped in accordance with their wheel arrangement, and it will be noticed that the general tendency is for BD to show a low value for locomotives designed for high-speed service, and a high value for low-speed service. In Table II. the grouping has been made more general, the locomotives being classed together according to the service for which they are suitable. The Prairie, Atlantic and American type engines are placed together as high-speed engines, the Moguls and Consolidations make up the low-speed class, while the Ten-wheelers hold a medium position. In the averages thus obtained the relation of BD to the class of service is well marked. In round numbers BD averages 650 for the high-speed engines and 800 for the low-speed engines. The ten-wheel engines give intermediate values, with an average of about 750. As a matter of interest the detail figures for the Prairie and Atlantic type engines are given below:

| Type and Road. | Cylinders in Inches. | Drivers in Inches. | Boiler Pressure | Heating Surface | BD |
|---|---|---|---|---|---|
| **Prairie Type:** | | | | | |
| 1. Illinois Central | 20 x28 | 75 | 200 | 3,534 | 541 |
| 2. Chicago, Burlington & Quincy | 20 x24 | 64 | 200 | 2,888 | 568 |
| 3. Lake Shore | 20½x28 | 80 | 200 | 3,362 | 594 |
| **Atlantic Type:** | | | | | |
| 4. New York Central | 21 x26 | 79 | 200 | 3,505 | 556 |
| 5. Buffalo, Rochester & Pittsburgh | 19½x26 | 72 | 200 | 2,950 | 572 |
| 6. Chicago Northwestern | 20 x26 | 80 | 200 | 3,016 | 590 |
| 7. Illinois Central | 20 x28 | 79 | 200 | 3,192 | 596 |
| 8. Long Island | 19½x26 | 76 | 200 | 2,658 | 633 |
| 9. Burlington, Cedar Rapids | 19½x26 | 75 | 200 | 2,569 | 655 |
| 10. Wabash | 19 x26 | 73 | 200 | 2,436 | 657 |
| 11. Central of New Jersey | 20½x26 | 85 | 210 | 2 967 | 658 |
| 12. Buffalo, Rochester & Pittsburg | 20¼x26 | 72 | 220 | 3,008 | 665 |
| 13. Paris, Lyons & Mediterranean | 17¼x26 | 84¼ | 213 | 2,095 | 666 |
| 14. Chicago, Rock Island | 20¼x26 | 78½ | 210 | 2,806 | 676 |
| 15. Central of New Jersey | 20½x26 | 85 | 210 | 2,967 | 679 |
| 16. Pennsylvania (E2) | 20½x26 | 80 | 205 | 2,640 | 723 |
| 17. Pennsylvania (E1 | 20½x26 | 80 | 185 | 2,320 | 741 |

It would be of considerable interest and advantage if the technical papers were to make it a rule, when describing locomotives, to give the ratio of adhesive weight to maximum tractive effort, of maximum tractive effort to heating surface, of heating surface to grate area, and also the quantity BD. In the course of the investigation leading to the present paper it has been found advantageous to express these ratios as quotients, as shown below. The figures in this example are taken from a consolidation engine.

$$\frac{\text{Adhesive weight}}{\text{Tractive effort}} = \frac{168{,}000}{41{,}100} = 4.08 \quad \text{(A)}$$

$$\frac{\text{Tractive effort}}{\text{Heating surface}} = \frac{41{,}100}{2{,}844} = 14.45 \quad \text{(B)}$$

$$\frac{\text{Heating surface}}{\text{Grate area}} = \frac{2{,}844}{49.1} = 58.00 \quad \text{(C)}$$

By multiplying the quotient B by the driving-wheel diameter D, the quantity BD is obtained. It has been found convenient to designate the three quotients respectively by the letters A, B and C. The application of these letters is easily remembered if it is noticed that the first quotient determines the ratio of Adhesion, the second the Boiler capacity, while the third relates to the Combustion.

*Slide Rule Method for Finding the Quotients.*—By the use of a slide rule the quotients are very quickly and easily determined. In the case given above the cursor is set to the tractive effort (41,000) on the fixed scale, and the slide is set so that the adhesive weight (168,000) is read under the cursor; then the reading on the slide above the end of the fixed scale gives A = 4.08. Keeping the cursor at the same setting, the slide is moved to bring the heating surface (2,844) under the cursor; then the reading on the fixed scale under the end of the slide gives the quotient B = 14.45, and the reading on the fixed scale under the driving wheel diameter (56) gives BD = 810. Another setting of the rule in the ordinary way gives the quotient C.

*Determination of the Relation of BD to the Steaming Capacity.*—The steaming capacity of a locomotive performing a certain service may be measured by determining the maximum possible steam production of the boiler and dividing it by the actual steam consumption for the service. The quotient thus obtained (hereafter referred to as Q), is obviously a direct measure of the capacity of the locomotive. If Q is large, the engine has considerable margin of reserve steaming power; if Q is equal to unity, the service is the maximum the engine can maintain; while if Q is less than one, the service is heavier than the engine can continuously maintain. Now it can be shown that Q is inversely proportional to the quantity BD. The following symbols will be used:

B = maximum tractive power divided by heating surface.

b = pounds of water evaporated per hour per square foot of heating surface, working at maximum power.

c = percentage of stroke at which cut-off takes place.

D = driving-wheel diameter in inches.
d = cylinder diameter in inches.
L = factor to allow for losses and consumption of steam not accounted for directly in the cylinders.
P = boiler pressure in pounds per square inch.
Q = water evaporated per hour by boiler divided by water consumed per hour by cylinders.
r = number of revolutions per minute.
S = heating surface in square feet.
s = stroke of piston in inches.
v = specific volume of steam at gauge pressure P.

The amount of water consumed by the cylinders and also the amount which can be evaporated by the boiler is then determined by the following calculation:

Cylinder Consumption:

0.7854 $d^2sc$ cubic inches of steam per *stroke*.
3.1416 $d^2sc$ cubic inches of steam per *revolution*.
3.1416 $d^2scr$ cubic inches of steam per *minute*.
188.5 $d^2scr$ cubic inches of steam per *hour*.
$188.5\ d^2s\frac{cr}{v}$ cubic inches of *water* per hour.
$6.786\ d^2s\frac{cr}{v}$ *pounds* of water per hour effectively consumed, or, taking account of losses by condensation, etc.
$6.786\frac{Ld^2scr}{v}$ pounds of water *consumed* per hour total.

Boiler Evaporation:

b = maximum number of pounds of water which can be evaporated per square foot of total heating surface per hour.
S = total heating surface in square feet.
bS = pounds of water is the maximum *evaporation* per hour.

$$\text{Hence, } Q = \frac{bSv}{6.786Ldscr}$$

$$\text{But, } B = \frac{0.85\ Pd^2s}{SD}$$

$$\text{Therefore, } BD = \frac{0.85\ Pd^2s}{S}$$

$$\text{And } QBD = \frac{0.85bPv}{6.786Lcr}$$

$$\text{Therefore, } QBD = \frac{bPv}{8Lcr}$$

Now Pv is for all practical purposes a constant for boiler pressures between 150 and 220 pounds per square inch, and if the mean value of 26,000 be taken for Pv in all cases, the error will in no case exceed 2 per cent., and for pressures in the neighborhood o. 180 lbs., will be very much less. Inserting this value for Pv, the above equation becomes:

$$QBD = \frac{3250b}{Lcr} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Now, applying this expression to two locomotives of similar design but of different dimensions working under similar conditions of cut-off and speed:

The cylinders, etc., being of equal efficiency, L will be the same in both cases.

The boilers having the same proportionate evaporative power, b will be the same in both cases.

Consequently, the cut-off and speed being the same in both cases, the right hand side of equation (1) will be the same for both engines and the values of Q will be to each other inversely as the respective values of BD. That engine showing the higher value of BD, will have the lower value of Q, and the smaller reserve of steaming power. The lower value of BD will correspond to the greater steaming capacity.

In the case of a locomotive working at maximum power, so that the steam consumption is equal to the maximum steam production, Q is equal to one and

$$BD = \frac{3250b}{Lcr} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

The importance of this equation will be recognized. The quantity BD is not only shown to be a proper measure of the steaming capacity, but a simple expression is obtained determining the proper relation between heating surface and cylinder capacity for given conditions of service.

If L, the proportion of steam used and wasted to steam usefully consumed, is known, and b the evaporative power of one square foot of heating surface, these values are inserted in equation (2), and c and r are given the values corresponding to maximum service determining the required value of BD. Under ordinary conditions it will be safe to put L = 1.10, assuming that 10 per cent. more water passes the injectors than is usefully consumed in the cylinders. This value being inserted, equation (2) takes the form:

$$BD = \frac{2950b}{cr} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

In using this expression it must be noted that b is the number of pounds of water evaporated from feed water temperature to the temperature of the working pressure; hence, if the evaporative capacity of the boiler is to be expressed in pounds of water evaporated from and at 212 degrees, the constant factor 2950 must be divided by 1.2, making the expression:

$$BD = \frac{2460b}{cr} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

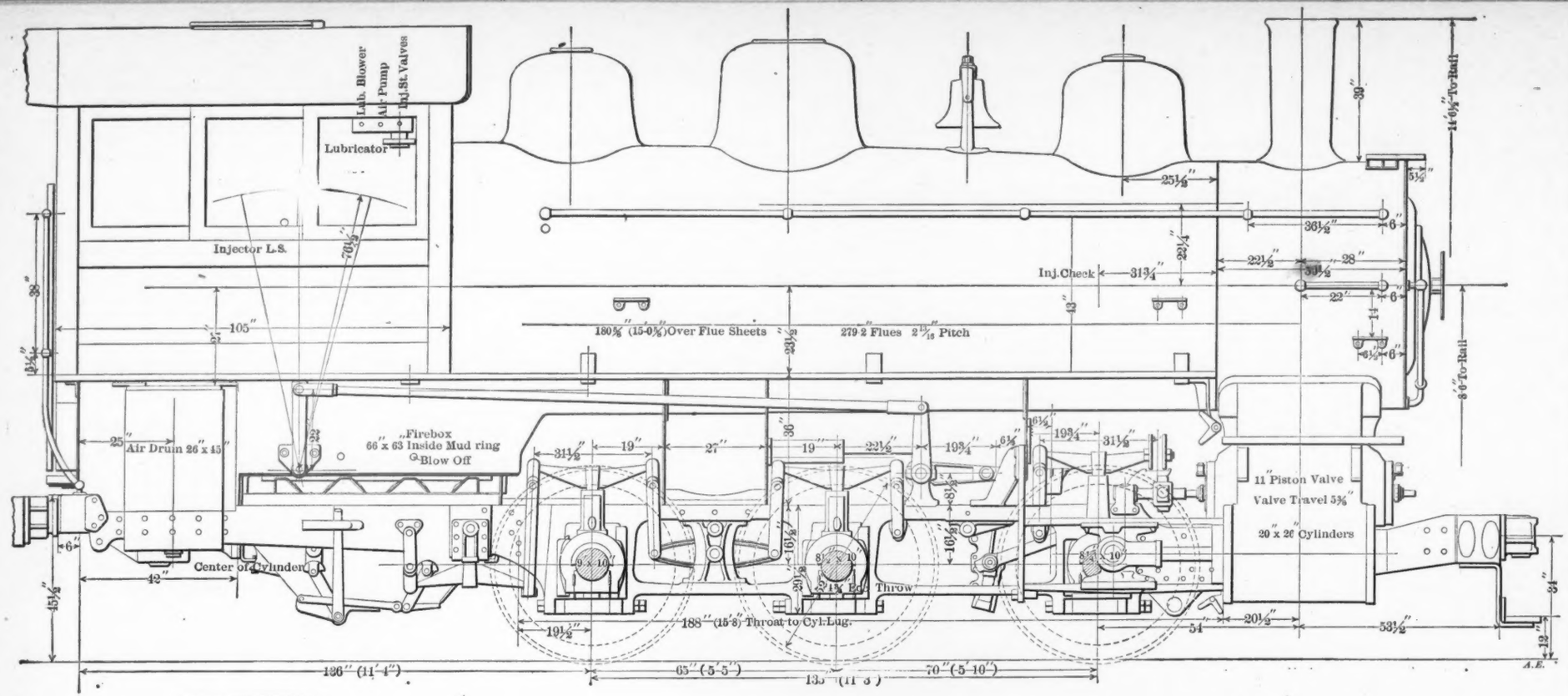
This expression is adapted for the calculation of the absolute value of BD for given conditions, but probably the widest and hence the most valuable use of the quantity BD will be in the making of comparisons.

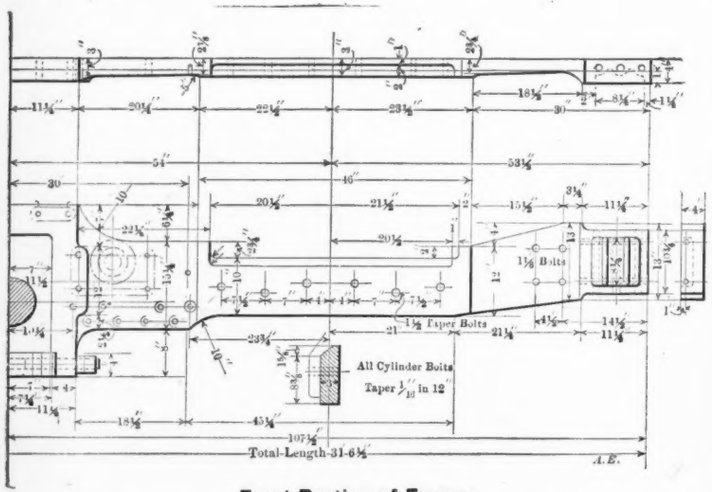
## LOCOMOTIVE AND CAR SCRAP.

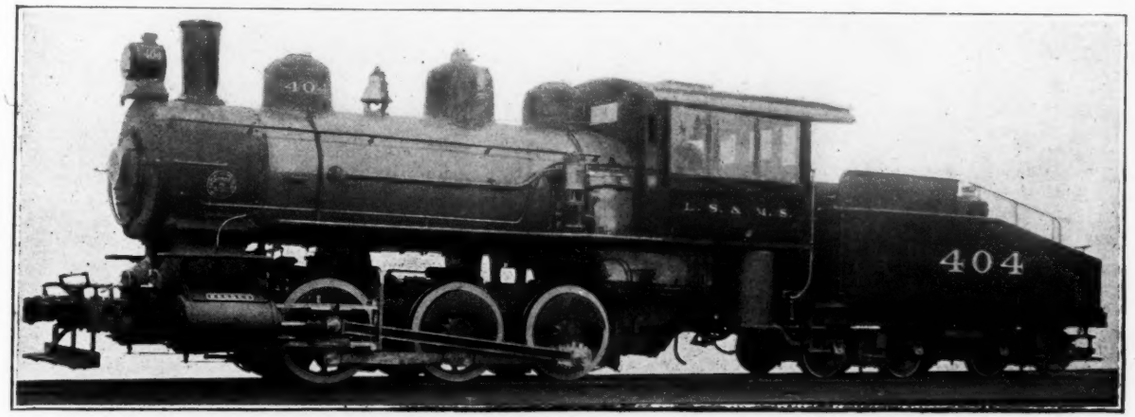
Locomotive and car scrap was the subject of a paper by Mr. T. A. Lawes before the Western Railway Club in September. The saving in the reclaiming of old bolts was shown to be $80 per month, in straightening old knuckles $96.60 per month, and by cleaning and using brass skimmings, instead of selling them, $125 per month. The corresponding investment has amounted to $700 in labor and material, and the saving represents a road having 140 locomotives and 11,000 cars. The conclusions of the author are as follows:

Scrap-bin floors should be on level with floors of box cars. The work of assorting scrap should be under the supervision of a man who has had experience in car repairs, that good material may be picked out and set aside for future use. Shears for cutting bolts, bolt-straightening machine and a bench with vise should be installed. The foreman of blacksmith shop should make several visits each day to scrap bins, inspect contents of same, and have set aside such material as he knows can be used to advantage. Good judgment must be used in regard to the working over of scrap materials; sometimes it costs more in the end than new material.

It would appear from tests and experiments (made by the author) that it is useless to ream a hole in a flue sheet which is less than 1-16 in. out of round, provided it is cylindrical, but if there is over 1-32 in. difference between the diameters at the two sides of the sheet, that the hole needs reaming, even although it is round. I do not claim that attention to these two points will stop the trouble from leaky flues, but I know that by watching them carefully, and reaming the holes at the proper time, our trouble will be reduced and, I believe, without any decrease in the life of the flue sheet.—S. W. Miller, in a paper read before the Western Railway Club.




**Front Portion of Frames.**

**Six-Coupled Switching Locomotive with Piston Valves and Wide Firebox—Lake Shore & Michigan Southern Railway.**

H. F. BALL, *Superintendent Motive Power.*

AMERICAN LOCOMOTIVE CO., BROOKS WORKS, *Builders.*

## SIX-COUPLED SWITCHING LOCOMOTIVE.

Lake Shore & Michigan Southern Railway.

These locomotives, built at the Brooks Works of the American Locomotive Company, were designed for heavy yard service with a view of meeting the exacting conditions of such work and reducing shop repairs to the minimum. They give a drawbar pull of 30,600 lbs. and are rated at 84 per cent. This road rates all locomotives with reference to hauling capacity, the heaviest consolidation type, Class B, illustrated in February, 1900, page 37, being rated at 100 per cent. This method of rating shows at a glance the standing of every type of locomotive with reference to its power, making the weakness and inefficiency of obsolete equipment stand out boldly. These engines have piston valves with inside admission and direct motion. The frames, which are of cast steel, are in one solid piece from end to end, and the portions under the cylinder are 3 x 10 ins. in section. The firebox is 62¼ by 72⅝ ins. in size. As shown in the line drawing, the spring rigging is within the frames. Another feature which will contribute to their usefulness is the hopper ash pan. This will reduce the time on the ash pits materially. We are informed that the engines are exceedingly satisfactory in service. These engines have very short front ends, without cinder pockets, the extension front being only about 6 ins. long in front of the cylinder saddle.

Six-Wheeled Switching Locomotive—Lake Shore & Michigan Southern Railway.

General Dimensions.

| | |
|---|---|
| Gauge | 4 ft. 8½ ins. |
| Fuel | Bituminous coal |
| Weight in working order | 139,000 lbs. |
| Weight on drivers | 139,000 lbs. |
| Weight engine and tender in working order | 227,000 lbs. |
| Wheel base, driving | 11 ft. 3 ins. |
| Wheel base, total, engine and tender | 43 ft. 2¾ ins. |

Cylinders.

| | |
|---|---|
| Diameter of cylinders | 20 ins. |
| Stroke of piston | 26 ins. |
| Diameter of piston rod | 3½ ins. |
| Size of steam ports | 2⅛ ins. by 25.5 ins. |
| Size of exhaust ports | 5½ ins. square |
| Kind of valves | Piston |

Wheels, Etc.

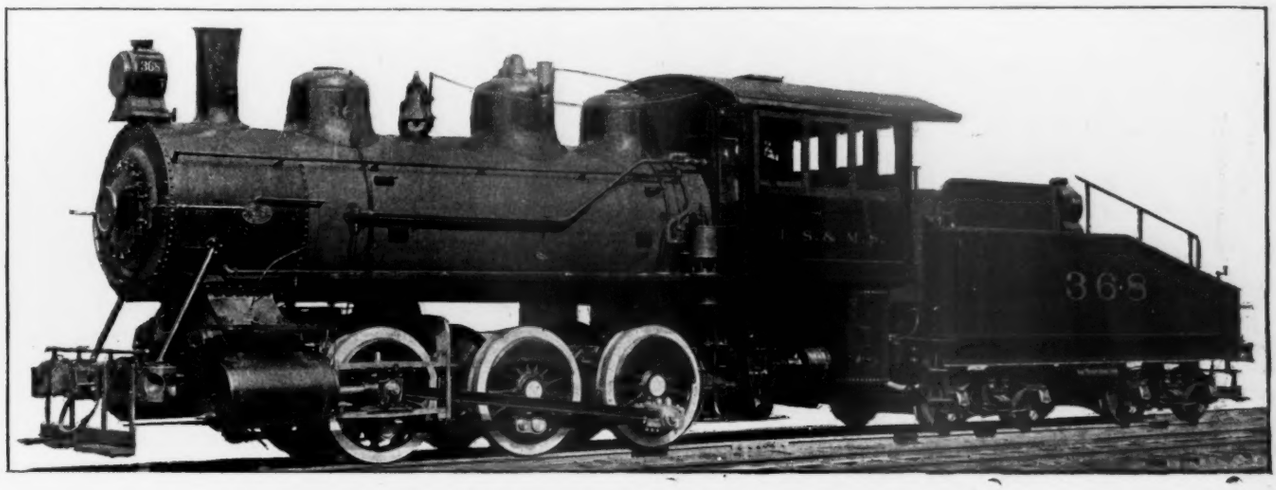
| | |
|---|---|
| Diameter of driving wheels outside of tire | 52 ins. |
| Material of driving wheel, centers | Cast steel |
| Thickness of tire | 4 ins. |
| Tire held by | Shrinkage |
| Driving box material | Cast steel |
| Diameter and length of driving journals | 8¼ and 9 ins. diameter by 10 ins. |
| Diameter and length of main crank pin journals | 5½ ins. diameter by 6 ins. |
| Diameter and length of side rod crank pin journals | Main pin 6⅝ ins. diameter by 5 ins., F. S. B. 4½ ins. by 4¼ ins. |

Boiler.

| | |
|---|---|
| Style | Radial stay |
| Outside diameter of first ring | 64½ ins. |
| Working pressure | 180 lbs. |
| Material of barrel and outside of firebox | Steel |
| Thickness of plates in barrel and outside of firebox | ⅝ and 8½ ins. |
| Firebox, length | 66 ins. |
| Firebox, width | 63 ins. |
| Firebox, depth | Front, 67 ins.; back, 64½ ins. |
| Firebox, material | Steel |
| Firebox plates, thickness | Sides, ⅜; back, ⅜; crown, ⅜; tube sheet, ½ |
| Firebox, water space | Front, 4; sides, 3½; back, 3½ |
| Tubes, number | 279 |
| Tubes, diameter | 2 ins. |
| Tubes, length over tube sheets | 5 ft. 0⅛ in. |
| Fire brick, supported on | Water tubes |
| Heating surface, tubes | 2,185.63 sq. ft. |
| Heating surface, water tubes | 20.74 sq. ft. |
| Heating surface, firebox | 123.51 sq. ft. |
| Heating surface, total | 2,329.88 sq. ft. |
| Grate surface | 28.2 sq. ft. |
| Ash pan, style | Hopper |
| Exhaust nozzles | 4⅞ and 5½ ins. diameter |
| Smoke stack, inside diameter | 15 and 17½ ins. |
| Smoke stack, top above rail | 14 ft. 6½ ins. |

Tender.

| | |
|---|---|
| Style | Sloping back |
| Weight, empty | 36,350 lbs. |
| Wheels, diameter | 33 ins. |



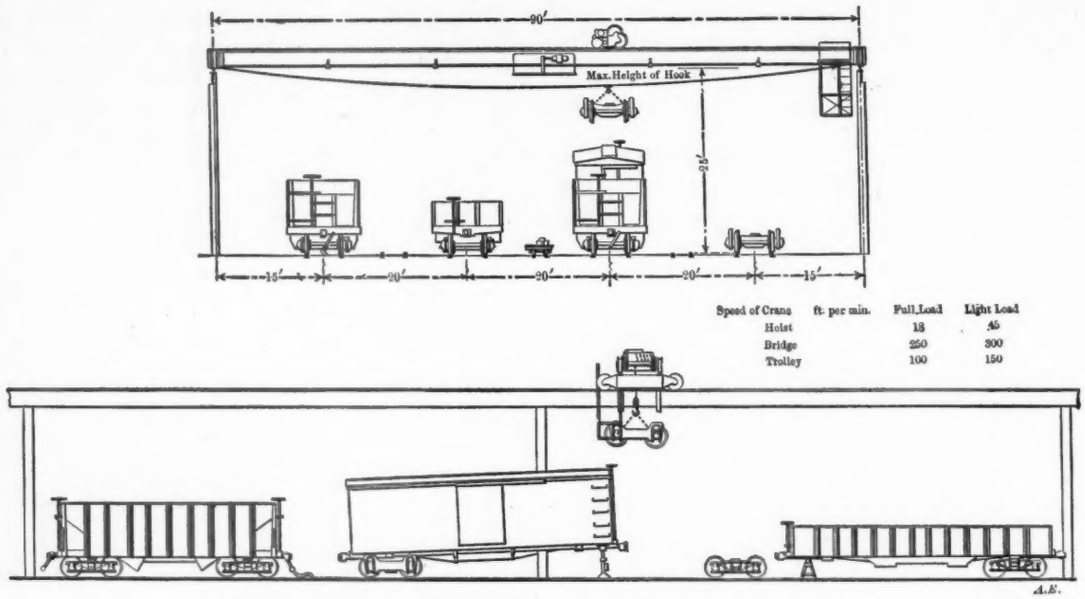

**Six-Coupled Switching Locomotive with Piston Valves and Narrow Firebox.**
**Lake Shore & Michigan Southern Railway.**

Note.—This design represents locomotives built at the Pittsburg Works last year. The one shown on the opposite page is the latest of this type on this road. The description applies to the Brooks design.

| | |
|---|---|
| Journals, diameter and length | 4¼ ins. diameter by 8 ins. |
| Wheel base | 17 ft. 0 in. |
| Tender frame | Channel steel |
| Water capacity | 4 000 U. S. gallons |
| Coal capacity | 8 tons |

Lithographed margin lines and titles for drawings are used in the mechanical engineer's department on the Lehigh Valley. Mr. Gaines has sent a tracing and letter describing the method. When a large number of sheets are lithographed at one time, and the tracing cloth is furnished in rolls, the average cost of cutting the cloth and lithographing the margins and general title is less than two cents per sheet. The average cost of doing the work by hand is about eight cents per sheet, and is not as uniform and regular as when lithographed. In lithographing these tracings, the trimming and margin lines, holes for punching and general titles may be put on as desired, and the tracing sheet is ready for the draftsman, who proceeds with the drawing without delaying to lay out the sheet. He completes the title and fills in the date when the drawing is finished.

Gas engines using blast furnace gas will be installed to furnish the blast for four new furnaces now building by the Lackawanna Steel Company at Stony Point, near Buffalo. This power has long been used in Europe, but this is its first appearance in this country for this purpose.




**Repair Facilities for Steel Cars.—A Suggestion by L. H. Turner.**

## REPAIR FACILITIES FOR STEEL CARS.

A topical discussion on "Modern Requirements and Facilities for Repair Tracks as Influenced by High Capacity Cars," at the recent M. C. B. convention, was opened by Mr. L. H. Turner, as follows:

"It is probable that all that can be said upon this subject is already thoroughly understood and appreciated. However, the introduction of heavy capacity cars has made it necessary to provide additional facilities to repair tracks, and these facilities have not been provided to compare with the necessity. Generally speaking, the improvements of this class of work are the last to be considered, but the opportunities for improved methods and money saving are just as great there as in the repair shop. The time has passed when any railroad company that attempts to maintain from seven to ten thousand cars at any one shop can afford to get along without electric cranes, compressed air and other modern conveniences.

"Tracks for heavy repairs with a capacity of 80 cars, allowing 50 ft. to each car, can be equipped with a 10-ton crane, 90-ft. span, at a cost of $23,000, or an investment at 6 per cent. of $3.78 per day. This crane, with an operator accompanied by two men, can raise and lower all cars, transport wheels, truck frames and the various kinds of material that has to be moved from place to place, at a cost not to exceed $10 per day. On the majority of shop tracks handling this number of cars, the cost of doing by hand that which can be done with the crane, will reach at least $40.

"Compressed air is another very important factor in quick and economical repairs to cars, and is simply indispensable where steel cars are to be handled. Natural gas in connection with compressed air is another valuable adjunct in straightening parts of all steel cars, or those with steel underframing. Pneumatic riveters, drills and paint spraying machines are all made necessary by the heavy capacity cars, and in many instances are equally as valuable in handling the lighter types.

"This blue print shows the plan of a repair yard that is thought to be one where work can be done quickly and cheaply. Each car can be reached by the narrow gauge track, which is very convenient for handling the lighter material and scrap.

"The cost of freight car maintenance is continually increasing, due to the increased size of equipment, scarcity of help, advance in wages and cost of material, and can only be kept down by providing all means that tend to reduce the number employed and get the greatest possible output from each man. This not only makes itself felt upon the pay rolls, but reduces the time the car is out of service, which is another source of revenue."

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An interesting article appeared in a recent number of *Popular Mechanics*, illustrating the 4,200-ft. aerial wire-rope tramway which the A. Leschen & Sons Rope Company, of St. Louis, Mo., built for the American Gold Mining Company, at Ouray, Colo. The line is 4,200 ft. long, extending from the works of the company, in the valley, up 2,100 ft. to the mouth of the mine. Any other mode of communication is impossible. The line consists of two stationary sustaining cables securely anchored at each end. The loaded buckets run on a rope 1⅛ in. in diameter, while the empties return on a 1-in. rope. The buckets are propelled by an endless steel wire rope ¾ in. in diameter, passing around an 8-ft. sheave at both terminals of the line, the one at the mine having a number of grips which clamp the rope tightly and afford the means to control the speed of the tramway when in operation; to this wheel are attached the brake-bands for stopping the tramway. The buckets are attached and detached automatically to and from the traction cable by means of patent clips, button-shaped, which are attached permanently to the cable. At the lower terminal of the line the tramway starts out a single span 2,100 ft. in length without any means of support between, which is the most remarkable feature of this tramway. The A. Leschen & Sons Rope Company are now building a tramway of this type at Encampment, Wyo., 16 miles long, which will be the longest tramway in the world.

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Semaphore signals for two or more routes on the Chicago, Milwaukee & St. Paul Railway are now made in accordance with a new standard. The arm at the top of the pole governs high speed or main line movements. The arm for diverging or low speed movement is smaller and is placed 17 ft. below the main line arm. When the main line signal is "cleared" the red light of the lower arm is covered and engineers of high speed trains do not run against red lights, which mean nothing to them. The lower arm is placed 10 ft. above the rail.

## NIGHT LIGHTING OF ROUNDHOUSES.

A new method of lighting the spaces between the locomotives in roundhouses has been tried on the Boston & Maine and is to be generally adopted on that road. A 16-candle power incandescent lamp with a silvered parabolic mirror, like those used on street cars, is mounted on the outer wall with its light directed between the engines and pointing toward the turntable. These lights are protected by air-tight boxes with glass fronts, and each has an independent switch to control the lamp without opening the box. The lighting is said to be much more satisfactory than that obtained by pendant lamps, even if two or three of these are used and hung from the roof in the usual way. The extra cost of the mirror is soon made good by the saving in the number of lamps required. Of course portable lamps for use under the locomotives must be provided in either case.

Superheated steam is employed by the Boston Elevated Railway in a new 4,500 h. p. compound engine recently put in by the Westinghouse Machine Company through Westinghouse, Church, Kerr & Co. The Babcock & Wilcox Company supplied the superheaters.

We are pleased to note that the Chicago & Alton Railway has established an employment bureau, the purpose of which is to recruit employes from among the people living along the line of the Alton road. Citizens living in towns upon and adjacent to the line of the Alton Railway are met by members of the bureau for the purpose of getting in touch with young men of good habits and high character who wish to become employes. Students in telegraph offices, clerks for the various departments, operators, brakemen, firemen, etc., are recruited from those whose records are kept by the bureau, the selections being made, after the mental and physical examinations forming a part of the Alton's requirements for employment have been passed, from those best suited and qualified.

If anyone is skeptical as to the necessity for examinations for vision, color sense and hearing, the experience of one of the large roads running out of Chicago should be convincing. On this road, says Dr. C. H. Williams, in a recent paper before the Western Railway Club, during the period from June 1, 1889, to November 30, 1901, there were rejected from among those applying for work, 1,888 men who could not pass the test for acuteness of vision, and 441 who were defective in their color perception to a dangerous amount. These figures mean, not only that the effectiveness of the operating force on this road was increased by the elimination of defective men, but also that other roads were getting more than their share of such persons; for many men rejected on one road find ready employment on another where no such tests are made. The figures also show that defects of acuteness of vision are much more numerous than those of color sense.

Two very unusual examples of rapid cutting were recently made at the Bethlehem Steel Company, with Taylor-White steel tools, which well illustrate the phenomenal qualities of that steel. In one instance a cut 1 3-16 in. deep was taken on a nickel-steel electric power house shaft mounted in a 90-in. lathe and revolving for a cutting speed of 25 ft. per minute, the rate of feed being 3-16 in. per revolution. In the other, a nickel-steel crank shaft for a protected cruiser was machined in a 50-in. slotter by a cut 1⅛ in. deep and a feed of 1-16 in. per stroke, the cutting speed being 18 ft. per minute. The former case corresponds to a removal of 66.78 cu. in. of metal per minute, or 2.318 cubic feet per hour. The great capacity of such rapid cutting can be better appreciated when it is considered that the rate mentioned corresponds to the removal of 1134.9 lbs. of steel per hour, or of 5.67 tons per day of 10 hours steady cutting.

It would appear from the following figures from the *Electrical Review* that electric lighting has little to fear from the competition of acetylene lighting: A ton of calcium carbide, which will generate 10,000 cubic feet of acetylene gas, requires 4,500 kilowatt-hours of electrical energy for its manufacture, and, in burning, this amount of acetylene gas will give out 250,000 candle-hours of light. But the same amount of electrical energy would, if used in incandescent lamps, produce 1,440,000 candle-hours, if used in the new Nernst electric glow lamps about twice as many, or nearly 5,000,000 candle-hours if used in open-arc lamps.

The rivets through the keel of the seven-masted schooner "Thomas W. Lawson," which was launched from the Fore River shipyards a short time ago, were nearly 5 ins. in length by 1¼ ins. in diameter. It was not possible to upset these properly with an ordinary yoke, one arm of which served as the anvil to resist the blows of the pneumatic hammer carried by the other arm. To have made the anvil heavy enough to accomplish the purpose would have produced a tool extremely awkward and difficult to handle in the cramped quarters underneath the keel. The difficulty was overcome by doing away entirely with the anvil and substituting a second pneumatic hammer. The two hammers, one on the end of each arm of the yoke, worked perfectly and there was no further trouble in making the rivets fill the holes completely. The strokes of the hammers were so exceedingly rapid that it apparently made no difference whether they approached synchronism or not.—*Iron Age.*

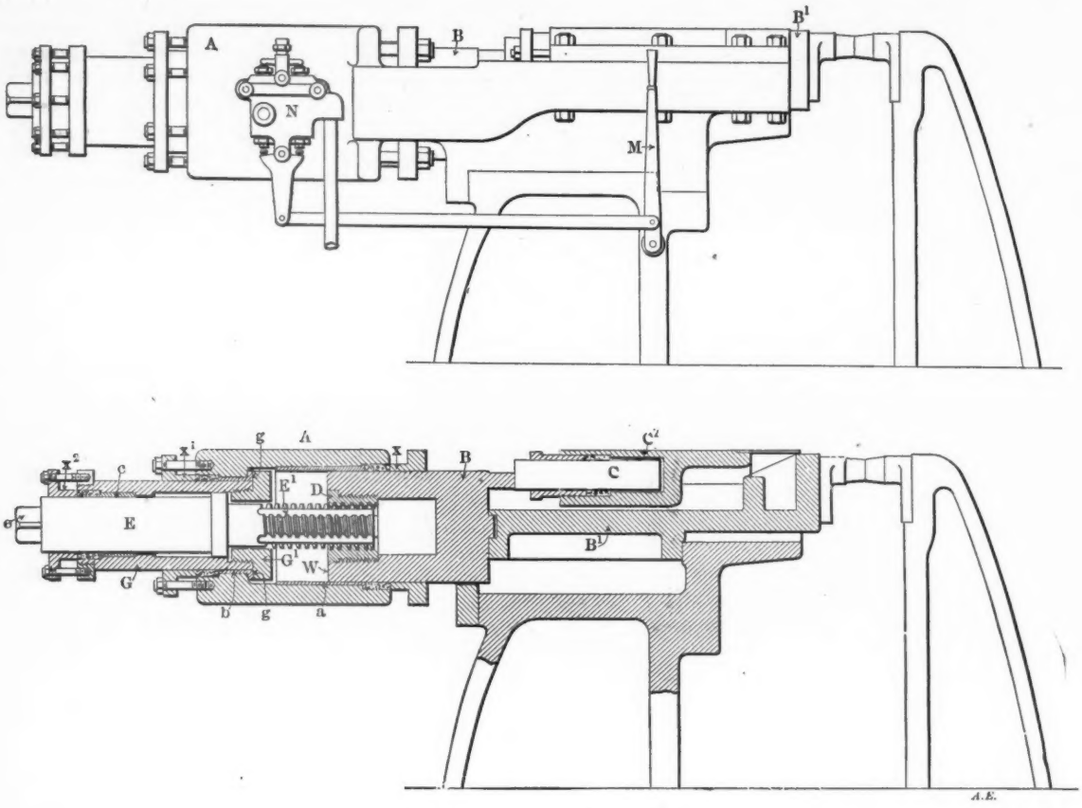
In a recent address before the Richmond (Va.) lodge of the National Association of Steam Engineers, Mr. Charles H. Garlick, national past president of the association, brought out the admirable position maintained by that society in the policy to which it holds. His remarks produced a profound impression, particularly the portion quoted below:

"The National Association stands out unique and alone as being the only large body of wage-earners in the world that does not resort to force and intimidation to accomplish its ends. It has 376 main and subordinate associations, located in every State and Territory in the Union with the exception of three. Its purpose is to educate the engineers in the art and science of steam engineering. The meeting-rooms are like schoolrooms, in which those that are better versed in engineering educate the less fortunate members of the society."

Mr. Garlick further stated that "the engineers who realized that coal, oil and other supplies cost money, and who, by their superior knowledge, could develop a horse-power with the least possible expense, were men who were to-day filling the best paid positions."

The maintenance of the policy of education in this great order of wage-earners for the accomplishment of their aims is the explanation of its great success. It is truly a noble and commendable policy. How often, in the trade unions and labor orders, incompetent old men are seen holding positions by virtue of priority only and thus keeping back better educated, progressive young men, whereas ability and education *should* govern.

A new burner has been perfected by the Safety Car Heating and Lighting Company. It is called the hexagon tip. Through its use the illumination afforded by a standard Pintsch lamp can be increased by about 40 per cent., while the additional consumption of gas amounts to less than 10 per cent. The tip is applicable to any standard four-flame Pintsch lamp—of which there are 140,000 in use—and it is fair to presume that the railroads will introduce this new tip as rapidly as it becomes necessary to replace the old ones now in service. One large railroad system in the East has already had many of its lamps fitted with the new burners, and all tips hereafter ordered by that company will be of the new type.




A.E.

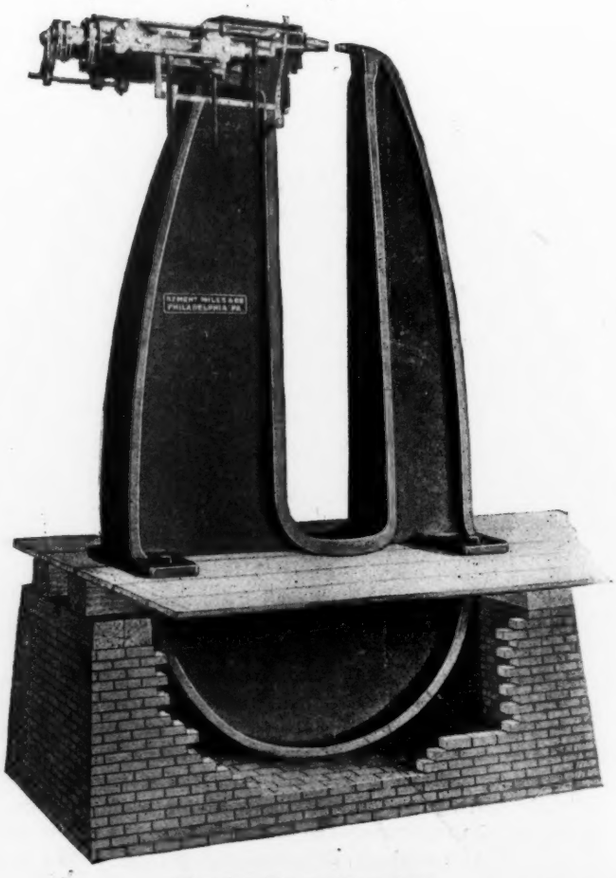
## TRIPLE-PRESSURE RIVETER.

With Outside Packing.

Bement, Miles & Co.

These engravings represent an interesting new development which every railroad officer in charge of shop equipment should investigate. They show a 124-in., 75-ton machine, with cylinder and frames separate and of steel. All of the packings are of hemp and all are outside of the cylinder—a most important feature, which we believe has not before been accomplished in this kind of machine. They may be renewed without dismantling the machine. Furthermore, three pressures, 25, 50 and 75 tons, are obtained with one valve and one accumulator pressure, and these pressures are all applied in a straight line to the rivet and close to the dies. There are very few water joints. The photograph shows also the valve for operating the crane. The reader will find the construction of this machine very interesting. It is remarkably simple.

To facilitate the description the sectional view is lettered. The cylinder A and the guideways for the riveting slide B1 form part of the frame. The cylinder A has a bushing a and a stuffing-box x, through which the plunger B extends. C1 is a return cylinder, with a plunger C bearing against the plunger B. The cylinder A is open at the rear end and terminates in an inwardly projecting flange, which holds in place the bushing b, which is packed by the stuffing-box x1. An auxiliary tubular piston, or sleeve, G, extends into the rear end of the cylinder and carries the head G1 at its inner end. In the interior of the tubular piston G is an annular rib, having back of it the bushing c and stuffing-box x2, through which the piston E extends. This piston has a head, forming a shoulder, and also a threaded stem E1 extending beyond the head. The threads are interrupted like those of the breech of a gun. The opposite end of the piston E is squared, so that it may be turned through a partial revolution by a



Showing Riveter Complete.

wrench. The main plunger B is hollow, and carries the bushing D with an interrupted thread corresponding with that of the extension of the plunger E. The three pressures are obtained by the main and the two auxiliary plungers, which are locked or unlocked, separately or together, with the main plunger by means of the stem with the interrupted thread.

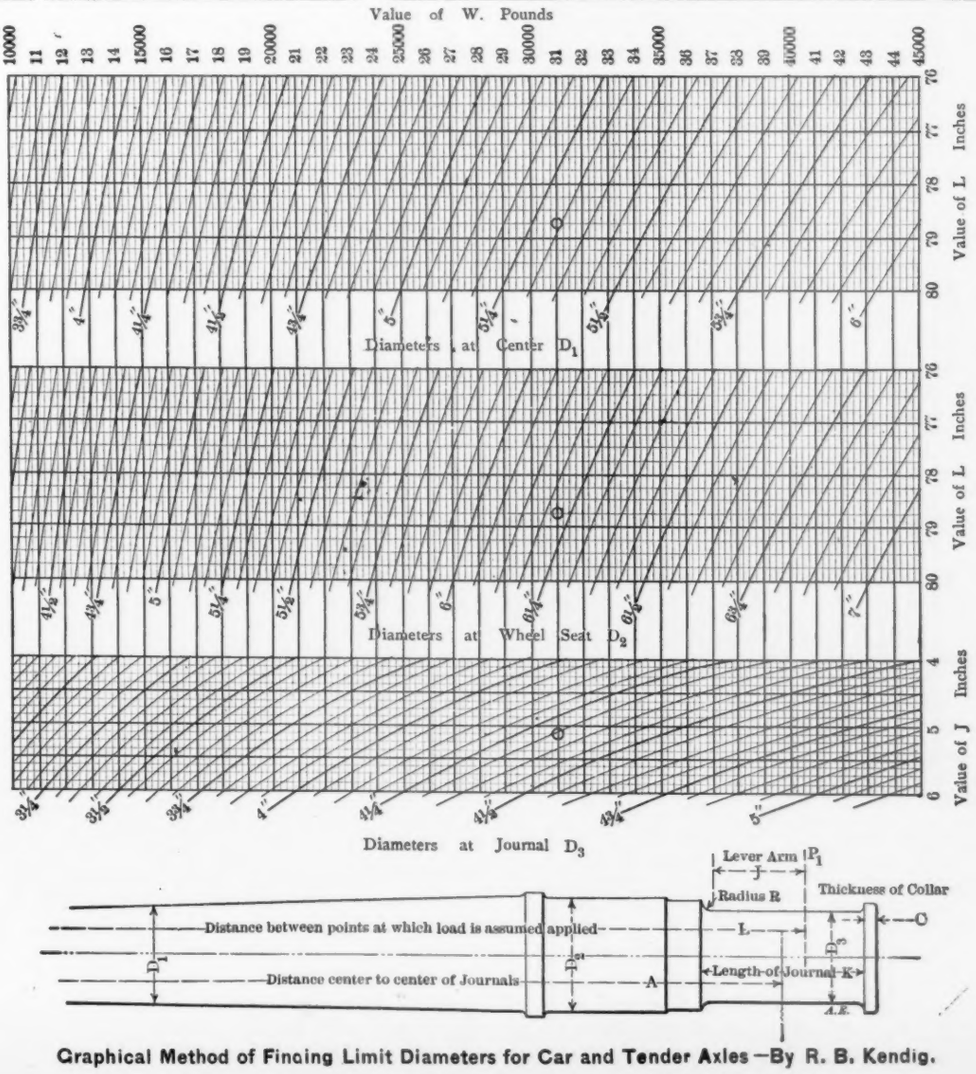
To secure the full pressure, the threaded stem is unlocked from the nut, and the pressure on the whole area of the main plunger is available. By turning the piston E when it is at the forward end of its stroke, and when the main plunger is in its forward position, as shown in the sectional engraving, the threaded stem E1 will engage the threads of the nut D, coupling it to the plunger B. This will reduce the effective area of the main plunger by the counter pressure on the piston E, and reduce the riveting pressure in this case to 50 tons. If the plunger B is moved into contact with the head G1 and the threads engaged, the pistons G and E will both move forward with the plunger B, and the force available at the dies will be only that due to the pressure against the annular surface g of the rear face of the head G1 of the hollow piston G. This gives the lighter pressure, or 25 tons, in this particular machine. One poppet valve gives the entire control.

These machines are made in three sizes, as follows:

| Pressure in tons. | Gaps in inches. | | | |
|---|---|---|---|---|
| 20—50— 75 | 100 | 124 | 144 | .... |
| 33—66—100 | .... | 124 | 144 | 204 |
| 42—84—125 | .... | .... | 144 | 204 |

One of these machines of the 17-ft. gap size has been installed at the Chicago shops of the Chicago & Northwestern Railway. Others have been furnished the Baldwin Locomotive Works, Brooks Locomotive Works, Union Pacific Railway, Lake Shore & Michigan Southern Railway (for the new Collinwood shops), and also a number of other boiler shops. The machine at Collinwood will have a 17-ft. gap. Additional information will be supplied by Bement, Miles & Co., Philadelphia, Pa.

It is undoubtedly the desire of every one of our readers to occasionally, if not frequently, purchase books upon engineering and scientific subjects, but the selection of the most suitable book from those offered by the publishers is most difficult if one is not able to see the books personally. It has been truly said that "titles of books are very misleading," as they are so in many cases, as one finds upon ordering a book without seeing it in advance. An innovation is offered in this line, however, by the Derry-Collard Company, recently formed, with offices at No. 256 Broadway, New York. This company proposes to make selections of books, to the best of their judgment, for those stating to them their wants and desires with respect to the purchase of books, and will forward the book selected to the purchaser for examination, whereupon he may pay for same if it is suitable, or return it if it is not just what is wanted. Any book published will be procured, and will be sent to anyone without any references and without any extra charge for the service. This proposition appears to be a boon to those desiring to purchase technical books, and we feel sure that the best of selections will be made, owing to the technical ability incorporated in the officers of the company.


Value of W. Pounds
Value of L Inches
Diameters at Center $D_1$
Diameters at Wheel Seat $D_2$
Value of J Inches
Diameters at Journal $D_3$
Lever Arm $P_1$
Radius R
Thickness of Collar
Distance between points at which load is assumed applied
Distance center to center of Journals
Length of Journal K

**Graphical Method of Finding Limit Diameters for Car and Tender Axles—By R. B. Kendig.**

Note.—This engraving is reproduced from that on page 288 to a larger scale.

## THE TRACTIVE FORCE OF LOCOMOTIVES.

By Edward L. Coster, A. M. Am. Soc. M. E.

The major portion of the following article, by Mr. Coster, is a compilation from the paper entitled, "Practical Tonnage Rating," presented at the 1901 convention of the Master Mechanics' Association, by Mr. George R. Henderson, S. of M. P., of the Atchison, Topeka & Santa Fe Railway, and from information supplied in the course of private correspondence with Mr. Henderson and others. It is believed that this article will prove of interest to our readers.—Editor.

The tractive force referred to in this paper is that which is available at the circumference of the driving-wheels, and will be designated by the symbol T. It is determined as follows:

At slow speeds—5 to 8 miles an hour—with the reverse lever in the corner notch and a cut-off of about 90 per cent. of the stroke, cylinder pressures will be obtained approximately as follows:

Initial pressure = .95 boiler pressure.

Mean effective pressure = .91 initial pressure.

Mean effective pressure = .86 boiler pressure.

Allowing 8 per cent. for internal friction = .92 M. E. P.

Mean available pressure = .80 boiler pressure.

This allows for the friction of pistons, valves, eccentrics, etc., but not for the resistance to motion which must be considered with the train. (For a treatment of train resistance, refer to "Momentum and Acceleration," by Mr. F. J. Cole, American Engineeer, June, 1901, page 167.) For the maximum available tractive force we have for single-expansion engines:

$$T = \frac{p \times .7854\, d^2 \times 4s}{3.1416\, D} = \frac{p\, d^2\, s}{D} \quad \ldots\ldots (1),$$

where p = mean available pressure in pounds per square inch;
d = diameter of cylinder in inches;
s = stroke in inches,
and D = diameter of driving-wheels in inches.

We can also write:

$$T = \frac{.8\, P\, d^2\, s}{D} \quad \ldots\ldots (2),$$

where P = working boiler pressure in pounds per square inch.

For two-cylinder compounds, when operating compound:

$$T = \frac{.8\, P\, d_l^2\, s}{D\,(r+1)} \quad \ldots\ldots (3),$$

where $d_l$ = diameter of low-pressure cylinder in inches, and

$r$ = ratio of cylinder volumes $= \frac{d_l^2}{d_h^2}$.

For two-cylinder compounds when operating simple:

$$T = \frac{.8\, P\, d_h^2\, s}{D} \quad \ldots\ldots (4),$$

where $d^h$ = diameter of high-pressure cylinder in inches. (This, of course, assumes the adhesion of the engine to be sufficient to allow it to develop this tractive force without slipping.)

Formula (3) is based on the operation of the low-pressure cylinder alone, merely assuming that the high-pressure cylinder will have the same total effective piston pressure, and therefore perform the same work as the low-pressure cylinder. Thus formula (3) is really derived directly from formula (2), by substituting the low-pressure cylinder diameter and introducing the divisor, r + 1, which, when divided into "p," gives what might be called the intermediate receiver pressure necessary to maintain equally the work in both cylinders when they bear to each other the ratio "r."

Thus, if we consider a two-cylinder compound locomotive having a cylinder ratio of 1 to 2, (r = 2), it is evident that it will require twice as much mean effective pressure in the high-pressure as in the low-pressure cylinder in order to equalize the work between them. With 210 pounds boiler pressure we would, neglecting losses, require 70 pounds initial pressure in the low-pressure cylinder, and 210 pounds initial pressure in the high-pressure cylinder, since the latter pressure is opposed by the 70 pounds back pressure offered by the receiver pressure (which is also the low-pressure initial pressure), thus leaving 210—70 = 140 pounds effective pressure. Hence, to obtain the proper theoretical low-pressure initial pressure, we have $\frac{210}{3} = 70$ pounds; or $\frac{210}{2+1} = \frac{P}{r+1}$; from which it follows that the actual initial pressure $= \frac{.95\, P}{r+1}$; the mean effective pressure $= \frac{.91 \times .95\, P}{r+1} = \frac{.86\, P}{r+1}$; and deducting 8 per cent. for internal friction, the mean available pressure in the low-pressure cylinder $= \frac{.8\, P}{r+1}$; and similarly for all pressures and cylinder ratios.

Consequently, $T = \frac{\frac{.8\, P}{r+1} \times .7854\, d_l^2 \times 4\, s}{3.1416\, D} = \frac{.8\, P\, d_l^2 s}{D\,(r+1)}$;

as given in formula (3).

The converse of the foregoing will also be true, namely: the diameter of the low-pressure cylinder can be calculated from equation (3) when the ratio between the cylinder volumes has been determined. Thus, since $T = \frac{.8\, P\, d_l^2\, s}{D\,(r+1)}$, $T\, D\, (r+1) = .8\, P\, d_l^2\, s$; whence $d_l^2 = \frac{T\, D\, (r+1)}{.8\, P\, s}$, and

$$d_l = \sqrt{\frac{T\, D\, (r+1)}{.8\, P\, s}} \quad \ldots\ldots (3a)$$

On page 22 of the 1899 edition of the catalogue of the Brooks Locomotive works it is recommended that "the ratio between high-pressure and low-pressure cylinder volumes for two-cylinder compounds be 1 to 2.25, and for four cylinder compounds 1 to 3.5, these being the most desirable ratios at the prevailing pressures."

The larger standard cylinders of Vauclain compound engines (classes $\frac{16}{30}$ to $\frac{30}{54}$, inclusive) have ratios varying from 1 to 2.68, to 1 to 2.94; the average ratio being 1 to 2.8. In designing these cylinders the aim has been to obtain ratios of as nearly 1 to 3 as equal cylinder work, and the use of convenient measurements, would permit.

In their latest design of four-cylinder balanced compound "Atlantic type" express locomotive, for the Northern Railway of France, MM. Du Bousquet and De Glehn have adopted a cylinder ratio of 1 to 2.71, which is found to give a higher thermal efficiency than the ratio of 1 to 2.42, employed in the earlier De Glehn compounds on this road.

For an analysis of the considerations governing the selection of cylinder ratios for compound locomotives, reference may be had to pages 72 to 79 of "Compound Locomotives," by Prof. A. T. Woods and D. L. Barnes.

Four-cylinder compounds will give values as follows:

When operating compound: $T = \frac{1.6\, P\, d_l^2 s}{D\,(r+1)} \quad \ldots\ldots (5),$

and when operating simple: $T = \frac{1.6\, P\, c_h^2\, s}{D} \quad \ldots\ldots (6)$

In the case of four-cylinder compounds, if we assume an equality of the work performed in all of the cylinders, it is only necessary to multiply formula (3) by 2, since we have double the number of cylinders. This is the explanation of the

factor 1.6, which appears in the numerator. Thus,

$$T = \frac{\frac{.8P}{r+1} \times .7854\ d_l^2 \times 4s \times 2}{3.1416D} = \frac{1.6\ Pd_l^2 s}{D(r+1)},$$ as given above.

Conversely, since $T = \frac{1.6Pd_l^2 s}{D(r+1)}$, $TD\ (r+1) = 1.6Pd_l^2 s$,

whence $d_l^2 = \frac{TD\ (r+1)}{1.6Ps}$, and $d_l = \sqrt{\frac{TD\ (r+1)}{1.6Ps}}$ .... (5a)

It should be observed that if equal work is not done in all of the cylinders the foregoing formulae will not be strictly true. (Equal division of work between the high and low-pressure cylinders of a tandem compound is not essential, as an inequality will not tend to produce transverse twisting of the driving axle, as in a two-cylinder compound, nor vertical tilting of the cross-head, as in a Vauclain compound.)

From the foregoing it will be readily observed that the mean effective pressure does not stand by itself in these formulæ, because, if we desired to work on mean effective pressure we would substitute .86 for .8 in formulæ (2), (3) and (4), and 1.72 for 1.6 in formulae (5) and (6). We should then have what might be termed the "indicated tractive force," from which we would be obliged to deduct the engine friction in order to get the net power of the locomotives.

In regard to the tractive force of compound engines working simple, it is assumed that the operation of the high-pressure cylinder is the same as in single-expansion engines, and that the pressure of the live steam admitted to the low-pressure cylinder is reduced sufficiently to produce a cylinder work equal to that of the high-pressure cylinder. Hence formulae (4) and (6); these are, however, strictly applicable only to locomotives provided with intercepting valves, and a direct exhaust from the high-pressure cylinder to the atmosphere.

For Vauclain compound engines, the Baldwin Locomotive Works give the following formulae:

When operating compound,

$$T = \frac{.66P \times .7854d_h^2 \times 4s}{3\ 1416D} + \frac{.25P \times .7854d_l^2 \times 4s}{3.1416D} = \frac{.66Pd_h^2 s}{D} + \frac{.25Pd_l^2 s}{D} = \frac{Ps\ (.66d_h^2 + .25d_l^2)}{D} \quad \ldots\ldots\ldots\ldots (7);$$

and when operating with live steam in the low pressure cylinder,

$$T = \frac{.56Pd_h^2 s}{D} + \frac{.34Pd_l^2 s}{D} = \frac{Ps\ (.56d_h^2 \cdot .34d_l^2)}{D} \quad \ldots\ldots\ldots\ldots (8).$$

In formula (7) it is assumed that the maximum mean forward pressure on the high-pressure piston = .91P, and that the mean back pressure (which is also the low-pressure mean available pressure) = .25 P. Hence, the high-pressure mean available pressure = (.91—.25) P = .66P; as given above.

In formula (8) it is assumed that the opening of the starting-valve and the consequent passage of live steam from the admission to the exhaust end of the high-pressure cylinder, reduces the mean forward pressure on the high-pressure piston from .91P (as in 7) to .90P, and increases the mean back-pressure, or low pressure mean available pressure, from .25P to .34P. Hence, the high-pressure mean available pressure becomes (.90—.34) P = 0.56P.

As the result of a number of tonnage rating tests and indicator cards, Mr. F. F. Gaines, mechanical engineer of the Lehigh Valley Railroad, has adopted for the maximum available tractive force of Vauclain locomotives during compound operation, the formula:

$$T = \frac{.71\ P\ d_h^2 s}{D} + \frac{.265\ P\ d_l^2 s}{D} = \frac{P s\ (.71\ d_h^2 + .265\ d_l^2)}{D} \quad \ldots\ldots\ldots (9),$$

in which the friction of the engine and all internal losses have been deducted, and the result obtained by the use of these figures Mr. Gaines recommends as available drawbar pull on straight, level track, at slow speed. By substituting the proper values for the maximum mean available pressures, formulæ (7) and (8) can, of course, be employed for tandem engines, and are also rendered applicable to cross-compounds by introducing 2 into each divisor.

While variations in these figures may sometimes be expected, they will in general represent safe deductions at the slow speeds mentioned above. As the speed of a locomotive is increased the value of T will evidently be reduced, the boiler being usually inadequate to maintain full pressure with the reverse-lever in the corner at a speed exceeding five to eight miles per hour.

In the absence of reliable information as to the average mean effective pressures obtained in compound locomotives when at high speeds, the available tractive force of these engines under such conditions may be approximately determined in the following manner:

In his discussion of Mr. Henderson's paper, Prof. W. F. M. Goss said that for the Purdue locomotive Schenectady No. 2 "the loss due to the machine friction of the engine is constant for all speeds." (Proceedings Am. Ry. M. M. Assoc., 1901, page 214.) Assuming this to be true for all locomotives, and taking this loss as equivalent, as before, to a reduction of 8 per cent. of the mean effective pressure, we have, after allowing for engine friction, .92 M. E. P., as given above.

Let it be required to find the tractive force of a given two-cylinder compound locomotive when at a translational velocity corresponding to a piston speed of, say, 700 feet per minute. Referring to the diagram, Fig. 1, given by Mr. F. J. Cole in the AMERICAN ENGINEER for June, 1900, page 176, we find that at this piston speed the mean effective pressure of a simple engine = .5 P. Hence, allowing 8 per cent. for internal friction, we have mean available pressure = .92 × .5 P = .46 P; and substituting this value for .8 P in formula (3), we obtain

$$T = \frac{.46Pd_l^2 s}{D\ (r+1)}.$$

Had the above hypothetical case been that of a four-cylinder compound, then, substituting 2 (.92 × .5) P = .92 P for 1.6 P in formula (5), we have

$$T = \frac{.92\ P\ d_l^2 s}{D\ (r+1)};$$ and similarly for other piston velocities.

The available tractive force of a two-cylinder compound locomotive when the piston speed is 700 ft. per minute, can also be approximately determined as follows:

Equating formulæ (2) and (3), and solving for d, we have

$\frac{.8Pd^2 s}{D} = \frac{.8Pd_l^2 s}{D(r+1)}$; whence $d = \sqrt{\frac{d_l^2}{r+1}}$ = the diameter of the equivalent simple cylinders. Substituting this value for d in formula (2), and taking the mean available pressure = .46P, as before, we obtain $T = \frac{.46Pd^2 s}{D}$.

Similarly, for a four-cylinder compound, equating formulae (2) and (5), we have $\frac{.8Pd^2 s}{D} = \frac{1.6\ Pd_l^2 s}{D\ (r+1)}$, whence $d = \sqrt{\frac{2d_l^2}{r+1}}$;

or, equating formulae (2) and (7), we obtain:

$\frac{.8Pd^2 s}{D} = \frac{Ps\ (.66d_h^2 + .25d_l^2)}{D}$, whence $d = \sqrt{\frac{.66d_h^2 + .25d_l^2}{.8}}$ = the diameter, of the equivalent simple cylinders. Substituting this value for d in formula (2), and taking the mean available pressure = .46P, we have $T = \frac{.46Pd^2 s}{D}$; and likewise for other piston speeds.

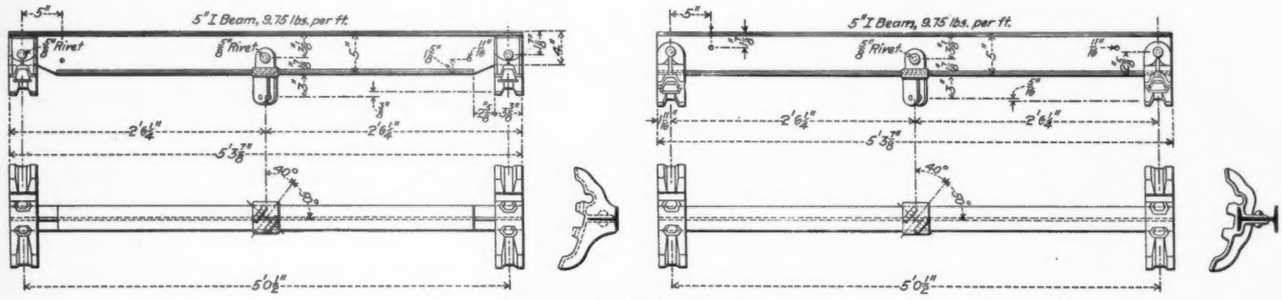
While the foregoing analysis is approximately correct, it should be observed that as compound locomotives consume less steam and operate with a later cut-off than similar single-expansion engines performing the same work, the reduction in mean effective pressure accompanying a given increase of piston speed is probably not so great in compound as in simple en-

gines; hence at high speeds, the actual tractive force of the former will probably be somewhat in excess of that given by the above formulæ. For tonnage rating purposes, this discrepancy constitutes an error on the side of safety.

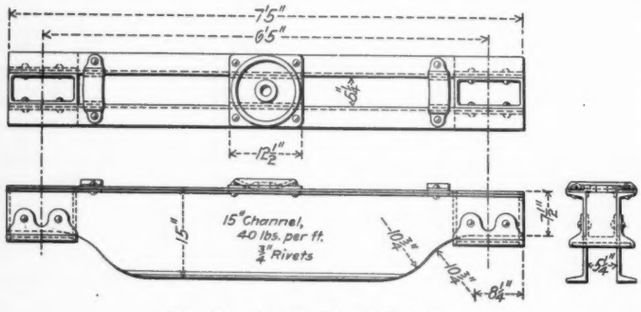
## VANDERBILT TRUCK BOLSTER AND BRAKE BEAM.

This truck bolster is built up of 15-in. 40-lb. channels placed 5¼ ins. apart, with the lower portions of their ends cut away to fit into cast steel spring seats. They are secured together also by the side bearings and center plate. The spring seats are made in box form to fit between the channels and with exterior brackets, so that the rivets pass through three thicknesses of metal and hold the structure together, but without being subjected to strain from the load. This construction is used under cars of 100,000 lbs. capacity. It forms a beam of virtually uniform strength.

The brake beam is illustrated in two forms, both being constructed of 5-in., 9¾-lb. I-beams. In one both the flanges are continuous to the ends and the brake heads are fitted over one of the flanges and riveted to the web. In the other form one of the flanges is cut away at both ends and the heads are fitted to the T-shaped ends of the beam. This construction




The Vanderbilt Brake Beams.




The Vanderbilt Truck Bolster.

permits of slipping the brake lever fulcrum along to the end of the beam, where it may be slipped off without removing the brake heads. These brake beams are manufactured by the Buffalo Brake Beam Company, 100 Broadway, New York. The bolster and brake beams were designed and patented by Mr. Cornelius Vanderbilt.

## NEW TRANSPORT FACILITIES FOR WESTERN ONTARIO.

An arrangement has lately been made between the Pere Marquette and the Lake Erie & Detroit River Railway companies which will doubtless prove of vast importance to western Ontario. The Pere Marquette company has secured the right to run trains over the Lake Erie & Detroit River tracks from Port Sarnia, Ont., to Rondeau and Port Stanley, Ont., where connections are made with the car ferry to Conneaut, Ohio, thus making a short cut from the upper peninsula of Michigan to the Bessemer & Lake Erie road, and to the Eastern States. Supplying, as it does, nearly all the soft coal for western Ontario from the Ohio and Pennsylvania fields, this ferry is already of considerable importance, but it is expected this new arrangement will make the ferry system across Lake Erie a line of general traffic, adapted for passengers as well as freight. There is now but one ferry running across Lake Erie between Conneaut and Port Stanley, having a capacity of twenty-six to twenty-eight loaded cars, and makes twelve round trips per week; but it is proposed to add several steamers of equal or greater capacity, sufficient to meet all the demands of the new line. The distance from Port Sarnia to Conneaut, Ohio, is about 150 miles, half by land and half by water.

## WATER TUBE BOILERS IN MARINE PRACTICE.

The following quotation from the report of the committee appointed by the lords commissioners of the British Admiralty to consider certain questions respecting modern types of boilers for naval purposes may be of interest to our readers:

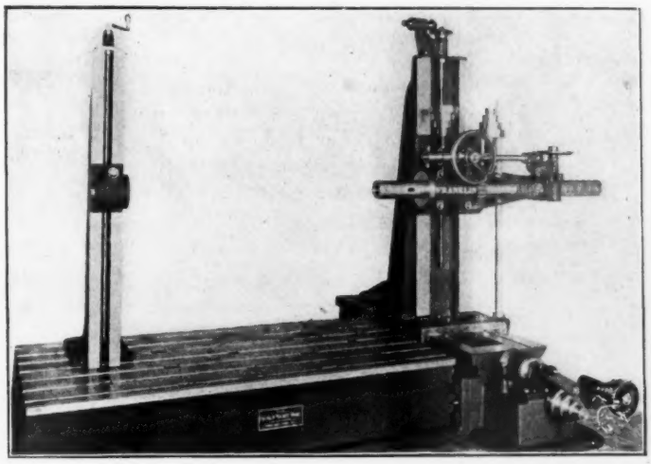
"In the course of their investigations the committee have watched the Babcock & Wilcox boilers fitted in the steamship 'Martello' of the Wilson line, employed in the Atlantic trade between Hull, Boston and New York, and copies of the reports of their inspections have from time to time been forwarded to their lordships. These inspections have taken place at the end of every round voyage for fourteen months, and the committee's opinion is that these boilers have stood the test of usage in the mercantile marine extremely well. The vessel has run about 91,000 miles since the boilers were put in, and has usually been less than a week in port at either end; the only repairs required have been those of the ordinary upkeep of any boiler, such as fire-bars, brickwork, etc., and only six tubes have required renewal. This opinion is strengthened by the inspections of boilers of the same type fitted in the 'Numidian,' the 'Buenos Ayrean' and the 'Turret Cape.' In the case of the last-named vessel the boilers have been in use seven years, and cannot have been as well looked after as they would have been in the navy, and their condition when examined recently was satisfactory. The committee have also examined and tested boilers of the same type in H. M. S. 'Sheldrake,' and find that, although they have been in use for four years, their condition is good and they have given little trouble.

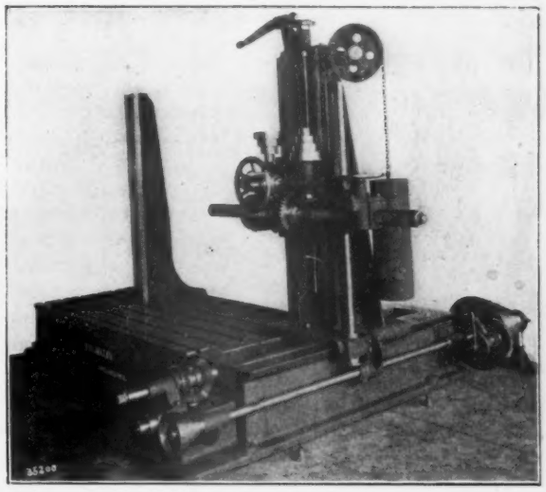
"From the information which has been brought to the notice of the committee, it appears that water tube boilers are being very little used in large ships belonging to the mercantile marine, and that their use in such ships is increasing very slowly. In the British mercantile marine the only type of water tube boiler installed in ocean-going vessels is the Babcock & Wilcox, in some ships of the Wilson and the Petersen-Tate lines, and in three ships of the Allan line; in these last, however, only one water tube boiler is fitted in each vessel, to assist the original cylindrical boilers. In the United States mercantile marine Babcock & Wilcox boilers are used to a small extent, principally in the ships plying on the Great Lakes, and in the American navy many Babcock & Wilcox boilers are in use."

It is interesting to note that throughout their investigations, which lasted over a period of nearly two years, the committee were only able to examine into the merits of one type of water tube boiler successfully operating in the merchant marine, and, as will be seen by the foregoing, this was the Babcock & Wilcox.

## FRANKLIN HORIZONTAL FLOOR-BORING, MILLING AND DRILLING MACHINE.

This new machine, designed and built by the Franklin Machine Works, Incorporated, Philadelphia, Pa., possesses a number of valuable features. While it conforms in general principles to more expensive and larger machines, it is capable of doing the boring and a large amount of the milling heretofore necessarily done on a long milling machine. It covers a specially large variety and wide range of work, being adapted to all kinds of boring, tapping, reaming, and various kinds of milling. It has a spindle of hammered crucible steel, 3 ins. in diameter, fed through a gun-metal sleeve, and has a No. 5 Morse taper hole in the end of the spindle, with a hole for a pin to secure boring bars, facing heads, etc., in position. The column carrying the spindle-head has an automatic feed of 42 ins. in either direction, the spindle-head has 30 ins. of vertical movement, and the spindle feeds 24 ins. in either direction. The feeds are arranged to be driven by power in any direction. For milling, the spindle-head and bar may be clamped in position. The wide range of work which it will do is sufficient recommendation for this machine. It will bore and face cylinders as large as 24 ins. in diameter, and will drill and tap holes as small as ⅜-in. It will mill long castings, cut keyways in long, heavy shafts, and yet occupies a small space in relation to the size of the work done. With a rotary facing-head it will do work ordinarily done on rotary planers. Many jobs formerly requiring the use of a heavy boring machine, where the work required raising and lowering to the bar, can be successfully done on this machine with the least possible amount of effort. The gearing throughout is very powerful and all of steel. Ten changes of speed are obtained from the driving-cone, which has five steps, and there are eight changes of feed for each step of the driving-cone. The platen is a strong, heavy, well-ribbed casting, and is provided with a plain or compound table, or both, if desired. This machine has been designed to meet a definite need, and it is very well received by the users of machine tools, who are becoming more and more discriminating in the selection of machinery every year. Further particulars may be obtained from the Franklin Machine Works, 1231 Callowhill street, Philadelphia, Pa.





**Horizontal Floor Boring and Milling Machine.**
**Franklin Machine Works, Philadelphia, Pa.**

Scale in gas-engine cylinder jackets in which hard water has been used can be effectually removed by filling the jacket with commercial muriatic acid, according to Mr. C. W. Andrews, Hamilton, O., at a recent meeting in Columbus of the Ohio Gas Light Association. It is allowed to stand in the jacket until the decomposition of the scale, with the attendant evolution of carbonic acid gas, is completed. One application has generally been found sufficient, if the scale is light.—Engineering Record.

## A LARGE ELECTRIC RAILWAY SYSTEM.

One of our largest interurban electric railways is the Hudson Valley Railway Company, which is a consolidation of the Stillwater & Mechanicsville, the Greenwich & Schuylerville, the Glens Falls, Sandy Hill & Fort Edward, and the Warren County railroads, and the Saratoga Traction Company. The company has now in operation over one hundred miles of electric road, running north from Albany and Troy to Saratoga, Lake George, and the Adirondacks. At the present time power for operating the system is derived from independent power stations located at Stillwater, Saratoga, Middle Falls, Glens Falls, and Caldwell, but, ultimately, power for operating the entire system will be developed on the Hudson River near Waterford.

For the operation of the road in the meantime, until this Hudson River power station can be completed, an interesting and somewhat unusual method will be made use of. The company has increased the capacity of the direct-current power station at Glens Falls, and also of the Caldwell station, by installing additional generators. In the power station at Glens Falls there will be installed a 250-kilowatt three-phase rotary converter, transforming from direct current to alternating current, with voltage-raising transformers. Power will thence be transmitted by a three-phase 11,000-volt transmission line to Caldwell, where lowering transformers and a second 250-kilowatt rotary converter, operating alternating current to direct current, will be installed to supplement the generating power of that station. At the company's power station in Saratoga there is to be installed a 400-horse-power engine and a 250-kilowatt, 2,200-volt, alternating-current generator, with raising transformers, from which power will be transmitted by a three-phase, 11,000-volt transmission line to a sub-station at Round Lake to supply power to the recently completed Saratoga division of the system.

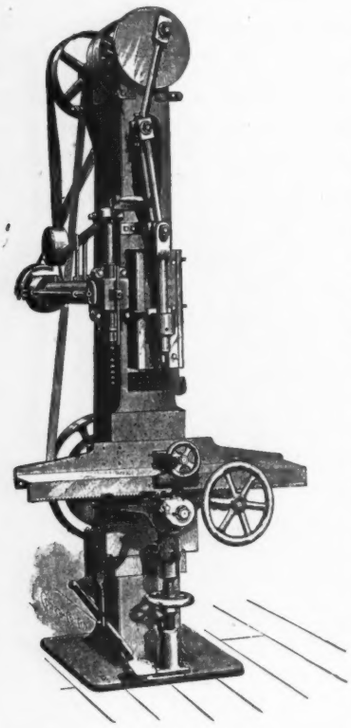
After the alternating-current generating plant is installed next year on the Hudson River near Waterford, the generating and sub-station apparatus now in use will be displaced by eight 300-kilowatt rotary converters, delivering direct current at 600 volts to the lines, and supplied by the main Hudson River power-house. The electrical apparatus for the temporary installations and for the permanent equipment of the sub-stations is to be furnished by the Westinghouse Electric and Manufacturing Company.

The importation of foreign scrap iron and steel is one of the features of the present unusual conditions of the metal market in this country, indicating the enormous demand for metals.

## GRADUATED STROKE MORTISING AND BORING MACHINE.

In our August issue was illustrated an improved tenoning machine manufactured by the Bentel & Margedant Company, Hamilton, Ohio. The accompanying engraving illustrates the hydrostatic graduated stroke mortising and boring machine, also made by this company, upon which several important improvements have been added.

A characteristic feature of this machine is the very strong construction, enabling it to work on heavy car and bridge work with hard wood as well as soft; also the ingenious stroke-graduating mechanism for gradually advancing the reciprocating chisel into the work. The old process of lowering the reciprocating chisel by gradually depressing a foot-treadle as the cutting proceeds is here obviated by a hydraulic mechanism which is set in action by merely depressing the foot-treadle at the base of the machine and holding it down. A liquid in a cylinder resists the reciprocating blows of the chisel, the gradual settling of the piston in the cylinder permitting the gradual lowering of the chisel into the work. This cylinder is shown in the illustration at the base of the machine, at the rear. This arrangement merely necessitates the raising of the operator's toe to give the treadle a one-half-inch movement, and also it effectually prevents breakages of chisels from irregular feeding, as the chisel bar is lowered uniformly and smoothly. The steel crank-shaft is seated in very long bearings, and the chisel bar is of improved design. The boring attachment is driven from the main shaft, and is controlled with tight and loose pulleys by a belt-shifting handle. The working table is raised and lowered by a heavy screw, centrally located, and provided with a long sleeve-nut. This machine is furnished with a series of chisels ranging from ⅜ to 1½ ins. in width, and the boring attachment will bore holes up to 6 ins. in depth. The table is 44 by 8 ins., and will receive material 18 ins. thick.



A relief association has been in operation on the Pennsylvania Railroad for a number of years, and it has recently been extended to the Grand Rapids & Indiana. Its funds are created by voluntary contributions at uniform rates, graded with reference to the rates of wages. The railroad company acts as trustee, and is responsible for the fund, paying any deficiency which may be required.

The amount of benefit in case of disability or death is graded in accordance with the class of service of the member and the amount of his dues. During eleven months of last year the employees of the Grand Rapids & Indiana received, on account of sickness, $2,507.20; accident, $1,684, and death, $4,500, making a total of $8,691.20 paid to employees of that company alone. Aside from the financial benefit derived from an association of this nature, it tends to bring the employees into more friendly relations with the company.

## PERSONALS.

Mr. W. F. Kiesel, Jr., has been appointed assistant mechanical engineer of the Pennsylvaia Railroad to succeed Mr. A. W. Gibbs.

Mr. Benjamin Welch, master car builder of the Southern Pacific, has retired after a continuous service of 39 years. He has not been in active charge of the department for about two years.

Mr. H. E. Smith has resigned as chemist of the Chicago, Milwaukee & St. Paul to accept the position of chemist and engineer of tests of the Lake Shore & Michigan Southern, with headquarters at Collinwood, Ohio.

Mr. J. F. DeVoy, formerly chief draftsman of the motive power department of the Chicago, Milwaukee & St. Paul Railway, has been promoted to the position of mechanical engineer, to succeed Mr. A. H. Thomas.

Mr. A. R. Breckenridge has been appointed master mechanic of the Des Moines, Iowa Falls & Northern Railway, with office at Iowa Falls, Ia. He was formerly for 15 years foreman of the machine shop of the Illinois Central at Waterloo, Ia.

Mr. Frank G. Benjamin has been transferred to the position of master mechanic of the Iowa division of the Chicago & Northwestern, with headquarters at Chicago. This is a promotion from a similar position on the Madison division.

Mr. H. T. Bentley has been promoted to the position of assistant superintendent of motive power and machinery of the Chicago & Northwestern from that of master mechanic of that road at Clinton, Iowa. His headquarters are at Chicago.

Mr. John McGie, master mechanic of the Central Railroad of New Jersey, has resigned to accept the position of general master mechanic of the Choctaw, Oklahoma & Gulf Railroad. Mr. McGie was formerly general master mechanic of the Montana Central.

Mr. A. W. Gibbs, assistant mechanical engineer of the Pennsylvania Railroad, nas been selected to succeed Mr. A. Kearney as superintendent of motive power of the Philadelphia, Wilmington & Baltimore, with headquarters at Broad Street Station, Philadelphia.

Peter E. Garrison, master mechanic of the Fonda, Johnstown & Gloversville Railroad, died August 22. He entered railroad service in 1868 in the shops of the New York, Lake Erie & Western at Port Jervis. In 1898 he was appointed to the position which he filled until his death.

Mr. B. D. Lockwood has been appointed mechanical engineer of the Wisconsin Central, with headquarters at Milwaukee. He has been chief draftsman of the motive power department of the Cleveland, Cincinnati, Chicago & St. Louis and has been connected with that road for a number of years.

Mr. Alexander Kearney has resigned as superintendent of motive power of the Philadelphia, Wilmington & Baltimore to accept the appointment of superintendent of motive power of the lines of the Baltimore & Ohio west of the Ohio River. He succeeds Mr. W. S. Haines and will have his headquarters in Pittsburgh.

## BOOKS AND PAMPHLETS.

**Universal Dictionary of Railway Officials, 1902. Compiled from official sources under the direction of S. Richardson Blundstone, Editor of the Railway Engineer. Representative for the United States: E. A. Simmons, 1333 Broadway, Brooklyn, N. Y.**

Each new edition of this indispensable directory has been an improvement upon the previous one, the eighth being no exception, and 16 pages have been added this year. The length of each road, a statement of the equipment and the names of the officers are given under the name of the road, and names are readily found by aid of a finding list.

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**"The Railway Transition Spiral." By Arthur N. Talbot, C. E., M. Am. Soc. C. E., and Professor of Municipal and Sanitary Engineering, University of Illinois. Third edition, revised and extended. Published by The Engineering News Publishing Company, New York, 1901. Price, $1.50.**

This "Transition Spiral" is among the best of the easement curves in use, and has met with much favor since it was first published in *The Technograph* in 1890. The book discusses in a simple way the proper length of spiral, in the determination of which speed forms an element. It derives in simple form the necessary formulæ for this spiral, and for further convenience, tables are added which show, for spirals of various chord lengths, the deflection angles, degree of curve, the co-ordinates at chord points, as also the total angle turned. These tables cover chord lengths of 200, 150, 125, 100, 80, 60, 50, 40, 30, 20 and 10 ft., thus making the transition spiral quite flexible. Other tables are also added for street railway use. The text further explains methods of use both for new curves and for realignment of old curves. The book is of convenient size for the pocket.

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"Record of Recent Construction, No. 36," is the title of an interesting pamphlet recently gotten out by the Baldwin Locomotive Works, of Philadelphia, which shows representative examples of the new types of engines resultant from the rapid development of recent years. A great variety of engines, both simple and compound and of all wheel arrangements, are illustrated and described by tables of principal dimensions, the text being duplicated in French. The frontispiece is a night view of Prince Henry's special train standing in the Milwaukee station of the C., M. & St. P. R. R., the engine of the train being an Atlantic Vauclain compound.

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The Santa Fé Railway has issued a folder, "Summer Outings in California," which deserves special mention. It is compact and attractive, with map and specially well-selected, fine pictures. The descriptions of the different California resorts are so very well written that the reader has a strong impulse to pack up and start directly. The only difficulty would be to choose a locality, since so many attractive places are described: Avalon, on the beautiful isle of Santa Catalina, lying in the Pacific eighteen miles from shore; Coronado, with its "Tent City" on the beach; the Yosemite Valley; the Sierras, with their wealth of trees—these are only a few of the many beautiful places inviting the summer tourist. Santa Barbara, Santa Monica, Mount Lowe, Long Beach, Sequoia National Park, Mount Whitney, Monterey, are among the attractive names, and even San Francisco itself, with its many beautiful surroundings, is highly praised as a summer resort. The author, whose name does not appear, has handled the subject admirably.

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The Franklin Machine Works, Philadelphia, have issued a new catalogue of their machine tools which should be in the hands of all users of boring, milling, drilling and cold saw machinery. This pamphlet illustrates a tool-room boring machine for work formerly done on an engine lathe or an expensive and heavy boring machine; a horizontal floor boring, milling and drilling machine for a large variety of work; a similar machine for heavier work; a plain milling machine for work requiring power and strength of design; larger machines, Nos. 2 and 3, of this description; a bar saw cutting-off machine, with a 15-inch saw; another with a 21-in. saw, with a capacity for 5-in. squares; a heavier machine, with 30-in. saw for 8-in. squares; a universal cold saw, with a pivoted work-table; a steel foundry saw, with a 40-in. saw blade for 13-in. round heads; a new pattern steel foundry saw, for smaller work; a crank-shaft saw, and two new automatic saw-sharpening machines, which will sharpen saws from 12 to 72 ins. in diameter. This machinery has all been designed and developed by this company, and is offered with the confidence of extensive experience. The pamphlet is well illustrated, and presents definite information in compact form.

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"Tour of the President to the Northwest." The Pennsylvania Railroad has issued a handsomely printed pamphlet giving in detail the itinerary of the tour of the President to the Northwest, including the stations at which he intended to stop, the times of arrival and departure of trains, a table of distances, list of members of the party and a well engraved map of the United States and Central America. Its style is admirable and its character unique.

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An ingenious card device, for displaying the colors of Dixon's Silica-Graphite Paint in such manner as will permit of an exact idea of each color, is being issued by the Joseph Dixon Crucible Company. The color chart carries with it suggestions as to the class of construction that can be protected with this paint, also instructions as to best methods of applying protective paint. The new color chart can be secured by request to the Joseph Dixon Crucible Company, Jersey City, N. J.

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The Safety Car Heating and Lighting Company, 160 Broadway, New York, have issued a very handsome pamphlet illustrating designs of Pintsch lamps which includes a number of new ones. Four new designs, appearing on pages 10, 11, 13 and 21 are exceedingly attractive and artistic. Such efforts to combine art with utility in railroad cars are commendable and it may be said that this company has not followed but led in the application of tasteful, handsome ornamentation to railroad cars. The lamps are numbered and each has an entire page to itself, being illustrated by an excellent engraving. The list includes gas, electric and combination lamps in a large variety. Twenty-nine varieties are presented.

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"Electric Locomotives for Surface Haulage." An 80-page pamphlet has been issued by the Baldwin Locomotive Works and the Westinghouse Electric and Manufacturing Company, illustrating electric locomotives specially designed to meet certain particular requirements and showing the adaptability of this power for industrial purposes. One of them is a 13-ton locomotive for the Atlantic Coast Lumber Company, giving drawbar pull of 4,500 lbs. at a speed of 6 miles per hour; another is a 5-ton, 20-in. gauge locomotive for the Maryland Steel Company, at Sparrow's Point, Md.; several mining locomotives are shown, and others in use in various large manufacturing establishments, including one operated by storage batteries. This catalogue seems to indicate a tendency toward extending the electric motor service of manufacturing plants to the yards to avoid the difficulties with repairs to steam locomotives. The pamphlet is standard size and very attractive.

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The Springfield Gas and Gasoline Engines, built by the Springfield Gas Engine Company, Springfield, Ohio, are described and illustrated in a 32-page pamphlet just received. Their engine was first brought out eleven years ago and it has made an excellent record. Since the first "Type A" was developed in 1891, improvements have been made by a systematic plan and the builders are prepared to meet present needs with engines which have proved satisfactory in design and operation. The valves are three in number, of the poppet type, and accessible because of being mounted on removable casings. These have gas tight joints and are independent of other operating parts. The valves are flat and have flat seats. Electric ignition is used, and both the igniter and the governor are well designed with large parts, all accessible. The igniter has but one spring and that a spiral, removed from the heat of the cylinder. The governor is of the "hit and miss" type which secures the same amount of gas for each charge and proportions the consumption to the varying load. All parts of the governor are large and instead of a revolving weight their construction employs a reciprocating weight at the end of a bell crank which is carried on a sliding bar, which forms part of the valve motion. This weight lags behind the motion of the slide, when the speed becomes too high and causes the igniter to miss. To aid in starting, the cylinder is relieved of a part of the compression by a device which opens the exhaust valve, allowing only enough of the pressure to escape to permit of starting easily. An air starter is supplied with engines of 25 h. p. and upward. This company builds either gas or gasoline engines and is prepared to meet the wants of engine users with thoroughly tried devices and construction. Simplicity is their most prominent feature as brought out by this pamphlet.

## EQUIPMENT AND MANUFACTURING NOTES.

Mr. T. H. Symington, president of the T. H. Symington Company, has found it necessary to give his entire time to the business of this company and give up his connection with the Gold Car Heating Company. He states that he is prepared to furnish journal boxes and dust guards for all classes of equipment in grey or malleable iron and in any quantities.

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The Detroit Graphite Company has received a large order for Superior Graphite Paint from Manila, P. I., and another from San Juan, Porto Rico. The increase in business requires continued service of men putting up new machinery and the plant is working regularly overtime.

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The Kennicott Water Softener Company has found it necessary, because of increased business among the railroads, to take into their own hands the management of sales, and they have withdrawn their agency from the J. S. Toppan Company and placed this important service in the care of Mr. William R. Toppan, who will have charge of the railroad department at 406 Great Northern Building, 77 Jackson Boulevard, Chicago.

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Mr. George Gould's private car Atlanta, now being completed at the car works at St. Charles, Mo., and which, it is stated, will be a veritable rolling palace, costing $150,000, is being equipped with the Consolidated "Axle Light" system of electric lights and fans.

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Mr. T. F. DeGarmo has been appointed eastern representative of the Falls Hollow Staybolt Company, with headquarters at 3116 Clifford street, Philadelphia, Pa. With a good experience in the railway supply business and an unusually wide acquaintance, Mr. DeGarmo will be a very valuable addition to the staff of this company.

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The Pennsylvania Railroad has placed an order for 250 locomotives with the Baldwin Locomotive Works. These will be for freight service and are to be delivered by the middle of next year. This is the largest single order for locomotives ever placed in this country, and it is reported that the road will soon order not less than 15,000 steel freight cars.

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For operating their turntables at the new Denver roundhouse, the Colorado & Southern have ordered two Leonard high-speed multiple cylinder engines of 15 horse-power each, from the Leonard Engine Company, of Philadelphia, Pa. This admirable engine was illustrated in the American Engineer, February, 1902, page 65. At Denver they are operated by compressed air.

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A new burner for Pintsch gas lamps has recently been perfected by the Safety Car Heating and Lighting Company. It is called the hexagon tip, and through its use the illumination afforded by a standard Pintsch lamp can be increased by 40 per cent., while the additional consumption of gas amounts to not more than 10 per cent. This tip is applicable to any standard 4-flame Pintsch lamp, and it is probable that the railroads will introduce it as rapidly as it becomes necessary to replace the old ones now in service. One large railroad system in the east has already a great many of their lamps fitted with the new burners and all tips hereafter ordered by that company will be of the new type.

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When firemen looked after the cleaning and varnishing of locomotive front ends, the attention of mechanical officers was not directed as it is now to the necessity for providing a durable paint for this purpose. On some roads the firemen have been relieved from this work and it is necessary to hire men especially to attend to it. The expense to a road having 1,000 locomotives may easily run up to $8,000 or $10,000 per year. The difficulty is to find paint which will stand the heat of the smokebox and prevent the rusty and burnt appearance which is so common. Readers will be glad to know of the experience of those who have used "Endura Enamel" for this purpose. It is presented in a little pamphlet issued by the Endura Company, 92 Griswold street, Detroit, Mich., and will be sent to anyone asking for it. This paint is said to meet the requirements for smokeboxes admirably.

One requisite to the safety and continued service of an elevator is a cable that will not break. Those who desire a good rope which will run a long time and relieve them from anxiety should investigate Leschen's Flattened Strand, made by the A. Leschen & Sons Rope Company, 920 North First street, St. Louis, Mo. This company has issued a neat little pamphlet entitled "Song of the Elevator," directing attention to their rope and its durability.

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The Chicago Pneumatic Tool Company, air-compressor department, reports that its plant, at Franklin, Pa., is operating day and night. Among recent sales of importance are two large compound compressors for the New York Central & Hudson River Railroad Company's Jersey Shore shops; two large compressors for the Readville shops of the New York, New Haven & Hartford Railroad; a compound compressor of 2,000 cubic feet capacity per minute for the Lake Shore & Michigan Southern's Collinwood shops, being a duplicate of the first compressor installed; a 1,000-ft. compound compressor for the St. Louis, Iron Mountain & Southern Railroad, and one of the same capacity for the new shops of the C., C., C. & St. L. Railway. They have also secured an order from the Government for the installation of a 1,000-ft. compound compressor at the Norfolk navy yard. Other sales include five large straight-line compressors to the American Lime and Stone Company, Tyrone, Pa.; a 1,000-ft. compound compressor to the Mobile & Ohio Railroad for their shops at Mobile, Ala., and one of 500 cubic feet capacity to the Louisville & Nashville Railroad.

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The Southern Pacific Railway Company, in conjunction with the Rock Island, has adopted the Consolidated "Axle Light" system of electric lights and fans for electrically lighting and ventilating all the new cars to constitute the Golden Gate Limited, which goes into service between Chicago and California on November 1. This is the same system of electric car lighting that is used on the Twentieth Century Limited of the New York Central and Lake Shore, the Pennsylvannia Limited and on the best trains of other leading railway lines, as well as on all private Pullman cars. One of the advantages of the "Axle Light" system is that each car carries its own lighting apparatus, making its own electricity as it moves, with the power taken from the revolving car axle and storing up sufficient electricity in batteries underneath the car to keep it illuminated while stationary, so that, no matter if the car should be detached from the main train and sent to some other point, it is always electrically lighted.

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Mr. J. W. Duntley, president of the Chicago Pneumatic Tool Company, has just returned from a five weeks' trip to Europe, and talks entertainingly of the business situation there. His company now owns the New Taite Howard Pneumatic Tool Company and the International Pneumatic Tool Company, of England, having recently taken over the latter company, and having reorganized these under the name of the Consolidated Pneumatic Tool Company. The Chicago Pneumatic Tool Company owns all the stock of the three English companies; the Consolidated Company being capitalized for £300,000, with Mr. A. W. Macnochie, a member of the British Parliament, as Chairman of the Board. They operate factories in London and in Chippenham, Wiltshire, England, for the partial production of the pneumatic tools in Europe. The Chicago Pneumatic Tool Company expect to arrange to duplicate their Detroit plant in Scotland for the production of tools required in the shipbuilding work in that country. The exhibition before the Ship Builders' Federation in Glasgow, which has recently been concluded, was highly successful, and the pneumatic tools have practically been adopted for all the shipbuilding work in the Scotland yards. The American workmen making the exhibit of pneumatic tools in shipbuilding are now in Germany, and from there will go to France for the purpose of making other exhibits. While in France Mr. Duntley took an order for 130 pneumatic riveters for one of the largest French ship yards. As an evidence of the growth of the pneumatic tool business of this company, Mr. Duntley cites the fact that their sales in 1895 amounted to $8,000, while in the current year they will amount to $3,000,000. The Chicago Pneumatic Tool Company now operates four of their own factories in the United States and have two factories under contract manufacturing their pneumatic tools, and are operating their pneumatic tool plant at Detroit and their air compressor plant at Franklin day and night, to supply the increased demand for their product.